IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Kleino, Thomas D.

Application No.: 10/649,139 Group No.: 3637

Filed: August 27, 2003 Examiner: M. Tolin

For: VIBRATIONAL REDUCTION SYSTEM FOR AUTOMOTIVE VEHICLES

Attorney Docket No.: 1001.039C1

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Declaration Under 37 CFR 1.132 of Todd R. Deachin

1) I am presently employed as Director of Product Design & Development by L&L Products, Inc. (L&L), which is the exclusive licensee to a commonly owned company named Zephyros and licensor, of the above patent application.

2) I hold a Bachelors of Science degree in Manufacturing Systems Engineering from Kettering University (formerly GMI Engineering & Management Institute), which I received in 1991.

3) I have been employed at L&L continuously since 1994, and specifically I have been engaged in engineering and development since 1987 of new products for automotive vehicle applications.

4) In connection with this Declaration, I have read this patent application, along with the claims that I understand are presently pending, and which I attach as **Exhibit A**.

5) I have studied U.S. Patent No. 5,358,397 (**Exhibit B**; "397 patent"), which names Ligon, Carter, and Hauptli as inventors.

6) The 397 patent is directed to what is called an "APPARATUS FOR EXTRUDING FLOWABLE MATERIAL," which is commonly owned by L&L.

7) I have studied U.S. Patent No. 5,266,133 (**Exhibit C**; "133 patent"), which names Hanley and Boos as inventors.

8) The 133 patent is directed to what is called a "DRY EXPANSIBLE SEALANT AND BAFFLE COMPOSITION AND PRODUCT."

9) I have personally inspected a part that is called "PART A" and a part that is called "PART B" as in Picture 1, which I attach as **Exhibit D** and Picture 2, which I attach as **Exhibit E**. PART A includes a strip of expandable material that has been attached to a door beam with fasteners and then expanded to "jump a gap" between the beam and a panel. PART B includes a strip of expandable material that has been extruded directly onto a door beam and then expanded to "jump a gap" between the beam and a panel.

10) To my knowledge and belief, the strip of expandable material for Part A and the strip of expandable material for Part B are formed using the same composition.

11) To my knowledge and belief, the beams were positioned relative to the panels in a substantially identical manner and as can be seen. When fasteners are employed, the expandable material, during expansion thereof, tends to sag and inconsistently adheres to the panel, beam, or both (sagging locations being labeled "C," typically in the areas between the fasteners that attach the strip of expandable material to the door beam). In contrast, when direct extrusion is employed (PART A), the expandable material bonds to the beam prior to expansion so that during expansion thereof, the expandable material does not significantly sag and adheres to the panel in a more consistent manner along the strip of the expandable material. This ability to resist sag and adhere in a consistent manner prior to and after expansion provides for a more robust connection between the beam and the panel for performing the desired damping function.

12) To my knowledge and belief, the PART A was employed by providing a door reinforcement, wherein the door reinforcement is a beam having an exposed external surface portion; applying, with an extruder and according to an automated process, the expandable vibration damping material in bonding contact over at least a portion of the exposed surface portion of the reinforcement prior to expansion; mounting the door reinforcement, with the expandable material thereon, to the door assembly such that the door reinforcement bridges a door frame; and expanding, by exposure to heat, the expandable vibration damping material to contact and adhere to the exterior panel structure including a panel; wherein the expandable material, during expansion thereof, fills a cavity between the door reinforcement and the

exterior panel structure for bonding the door reinforcement to the exterior panel structure within the claimed subject matter of the present invention.

13) To my knowledge, prior to August, 2000 and the present invention, extrusion of expandable material followed by mechanical fastening of that strip to the beam was believed to be the most efficient and effective technique for providing such a strip in a beam, particularly in those situations where expandable material was not a pumpable material and where the door beam needed to be transported after application of the strip to the beam.

14) To my knowledge, prior to August, 2000, there has not been a direct extrusion of expandable material directly onto a beam that would provide a bond between the material and the beam that is sufficient in strength to withstand transportation and assembly conditions that are present in the extruded material claimed in the present application. Examples of these conditions include, but are not limited to variations in temperature, contacting of the bonded beams against vehicle components during installation, shaking the vehicle during transporting to a dealership or during operation of the vehicle, each while maintaining the bond and placement of the material to the beam, prior to, during, and after expansion of the material.

15) Before the present invention, I believe it was common knowledge of those in the expandable adhesive material industry that previous expandable material were prone to sagging during application and/or expansion due to the forces associated with transporting the door beams and/or operation of vehicles including these door beam. As a result, manufacturers and designers of expandable adhesive materials were discouraged from directly applying expandable materials using extrusion and were skeptical that such extruded material would reduce sag.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Todd R. Deachin

Dated: 4/3/08

# EXHIBIT A

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(54) **VIBRATIONAL REDUCTION SYSTEM FOR AUTOMOTIVE VEHICLES**

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(60) Provisional application No. 60/225,126, filed on Aug. 14, 2000.

**Publication Classification**

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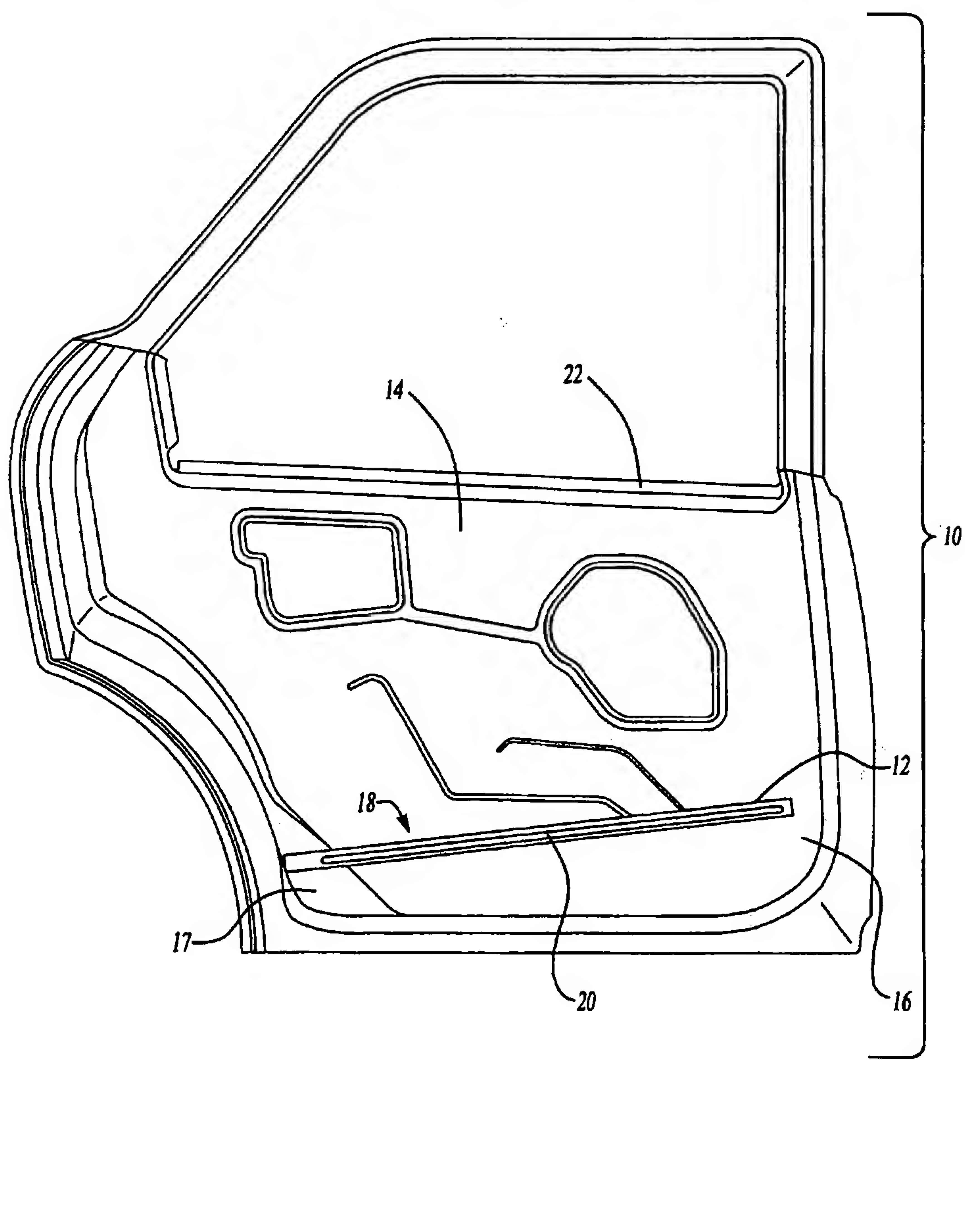
(52) **U.S. Cl.** ....................................... **296/146.6**; 296/1.03

(57) **ABSTRACT**

A vibration reduction and damping system for use in automotive closure panels, such as doors, lift gates, or other operable hatches comprising an intrusion device and an expandable material, such as a polymer-based foam, disposed along at lease a surface of the intrusion device prior to final assembly of the vehicle by the vehicle manufacturer. The system is activated as the vehicle undergoes the final vehicle assembly process, which activates and transforms the expandable material, preferably during an automobile paint operation, to expand, bond and fill the door assembly structure for vibrational damping and noise reduction.



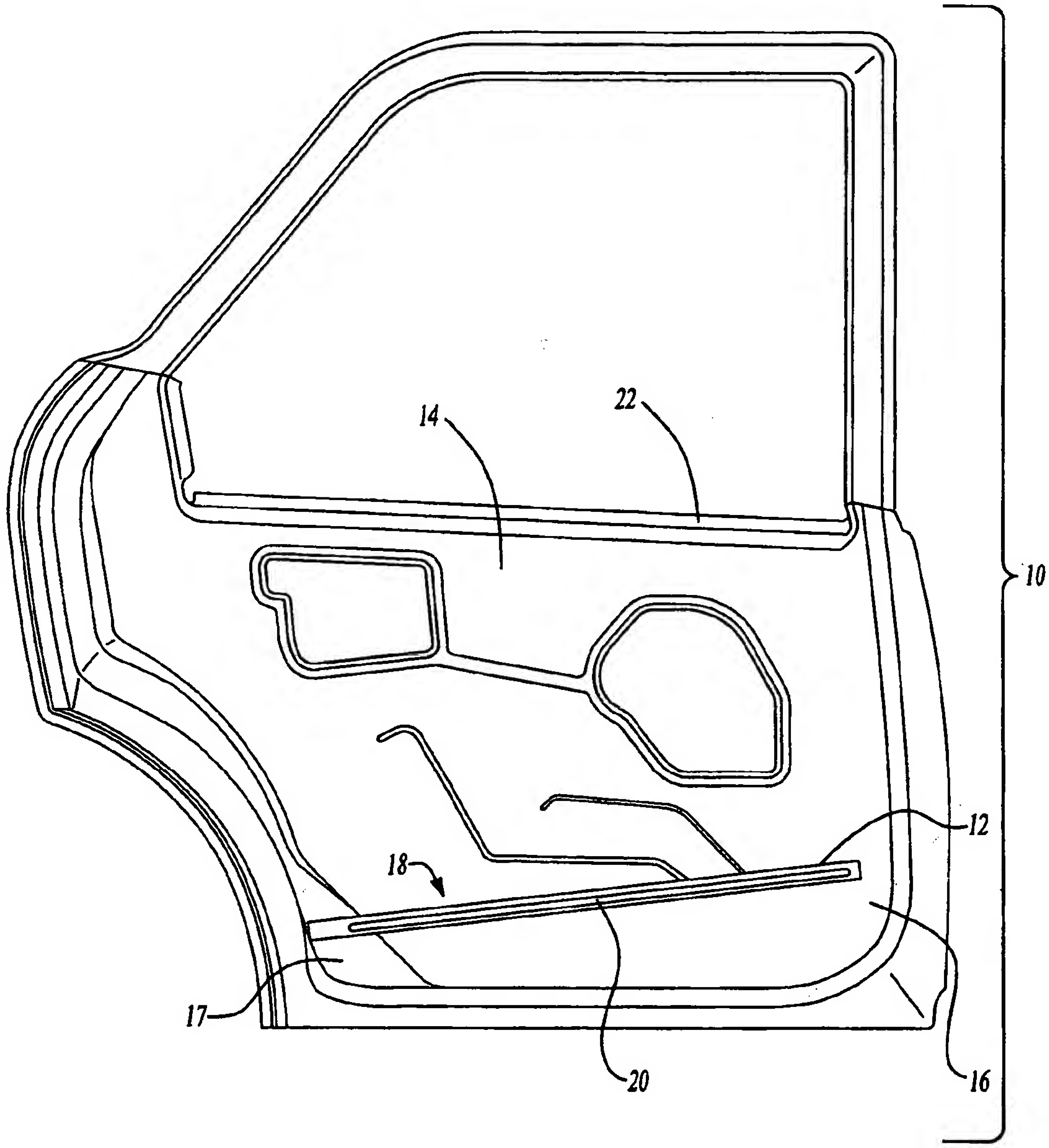



Fig-

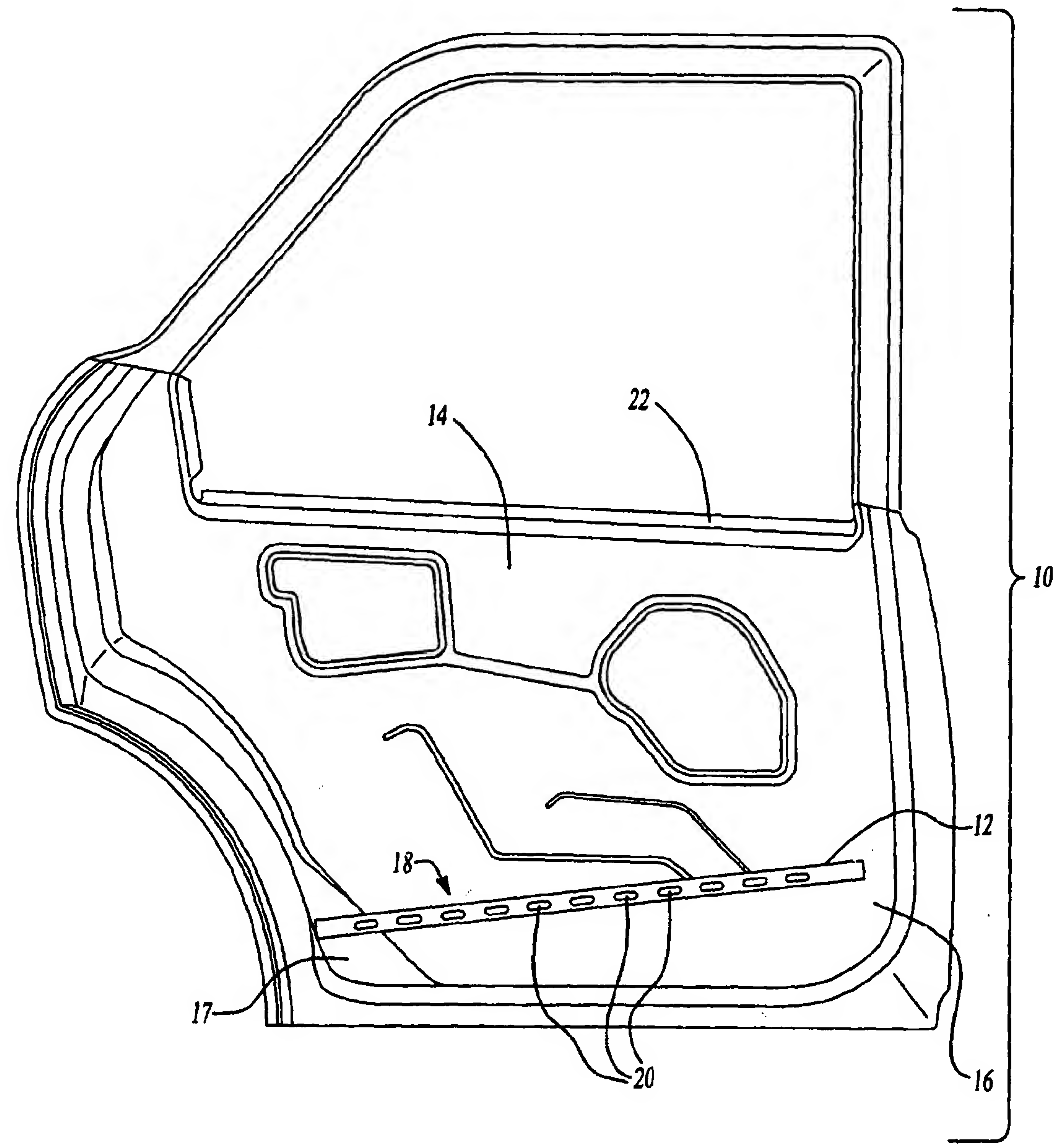



Fig-

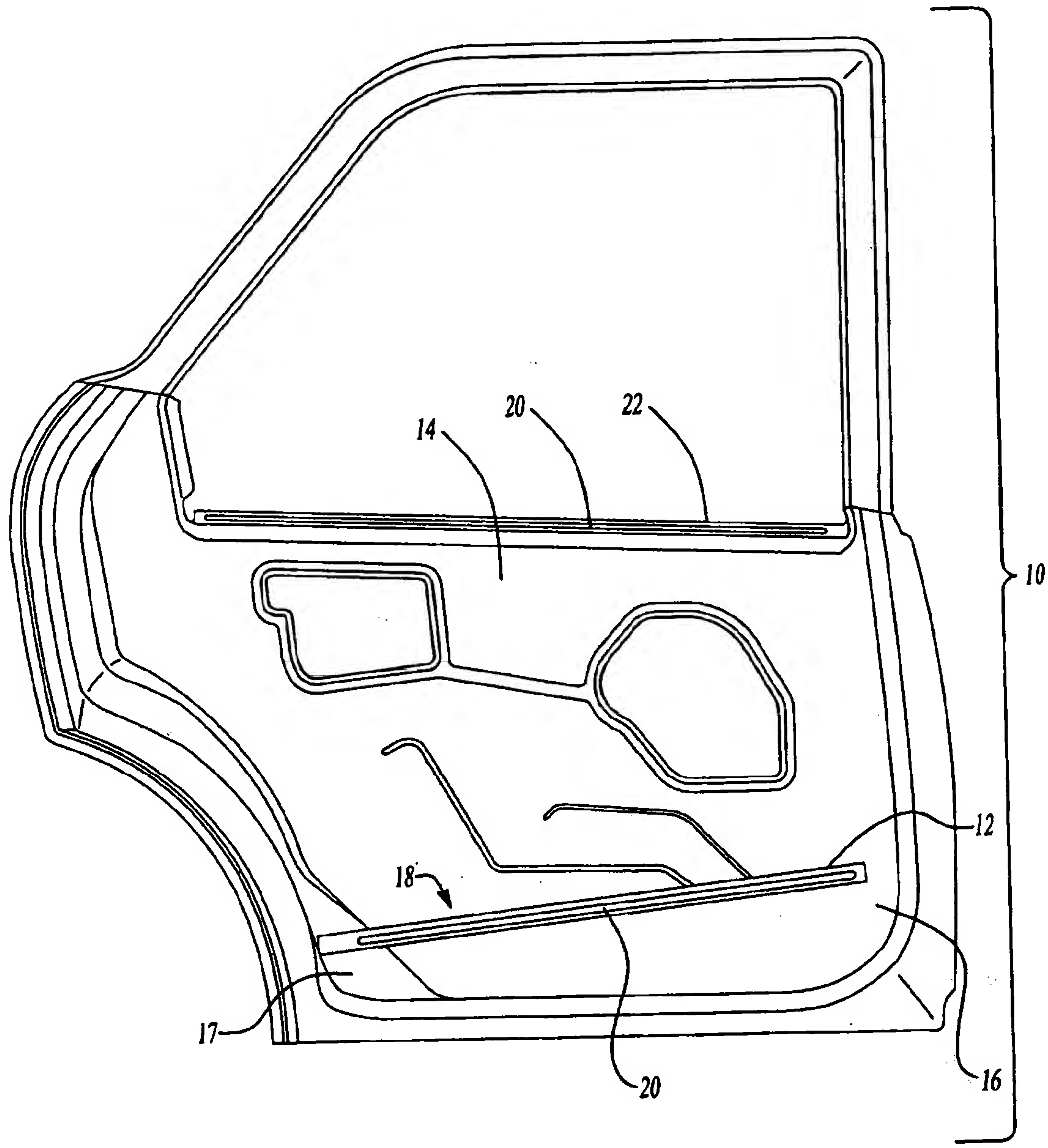



Fig-

# VIBRATIONAL REDUCTION SYSTEM FOR AUTOMOTIVE VEHICLES

## FIELD OF THE INVENTION

[0001] The present invention relates generally to improved methods and systems for reducing noise and vibration characteristics in an automotive vehicle. More particularly, the invention relates to an anti-vibration damping material or pellet application system integrated along portions of automotive closure panels, such as portions of an automotive door frame or other panel assembly used to facilitate passenger or cargo ingress/egress to the vehicle. The present invention is applied to selected portions of an automotive vehicle through extrusion techniques resulting in the reduction of vibration and the improvement of sound absorption characteristics of the automotive vehicle.

## BACKGROUND OF THE INVENTION

[0002] Traditional automotive panel assembly operations generally require a specific pre-assembly manufacturing step or process, which occurs prior to final assembly of the vehicle. Typically for automotive door assemblies, this step or process involves the application of chemical compositions to a traditional door intrusion beam after the beam is shipped to the vehicle manufacturer from the intrusion device supplier. This process requires the vehicle manufacturer to allocate tooling and manufacturing facilities for the intrusion device application at either a separate stamping facility where the door is assembled or in the final vehicle assembly plant. One such technique employs the use of pumpable products applied to the intrusion device in the form of "wet" compositions, which can remain tacky or may otherwise be applied to the beam in a non-uniform manner. For instance, one popular technique utilizes a pumpable product consisting of a thermally activated polymeric material, which upon heat activation expands and fills the space defined between the intrusion device and the outer door panel.

[0003] While these prior art system perform well and are advantageous in many circumstances, they often require a large capital investment to integrate the pumpable product into the chosen manufacturing facility, utilize a large amount of floor space and maintenance clean-up resources at the stamping facility or vehicle assembly plant, and require an additional manufacturing process and labor demand. In turn, the manufacturer is required to devote both financial and technical resources to develop tooling for the pumpable product as well as transportation costs, which adds potential cost and delay, particularly if changes to the vehicle structure are implemented during the design stages.

[0004] Accordingly, there is need for a simple low cost system that provides an integrated anti-vibration damping material, in the form of a "dry" chemical product which can be extruded-in-place within targeted portions of an automotive panel assembly to reduce vibration characteristics and which can be employed across a wide range of different sizes or shapes of cavities found in automotive vehicles.

## SUMMARY OF THE INVENTION

[0005] The present invention is directed to a vibration reduction system, and particularly one for automotive frame assemblies, such as (without limitation) vehicle door frame assemblies having a door intrusion device as well as any other automotive closure panel assemblies used in sliding doors, lift gates, or other designs used to facilitate the ingress and egress of passengers and/or cargo to an automotive vehicle. The system generally employs extrusion techniques in the form of a mini-applicator technology for facilitating the application of a dry chemical, anti-vibration damping material onto the intrusion device and/or other selected portion of the door frame, such as the belt line reinforcement, through an extrude-in-place process. It is contemplated that the material disclosed in the present invention functions as an anti-vibration dampener when expanded and bonded to the door intrusion device and optionally the inner and outer body panels, when the intrusion device, such as a intrusion device (now attached to the vehicle in the assembly operation), is processed through paint operations and process cycles typically encountered in a vehicle assembly plant. In one embodiment, the material is heat expandable and at least partially fills the cavity by cross-linking the door intrusion device and the inner and outer door panel during the painting operation thereby reducing noise and vibration characteristics of the vehicle as well as producing a more quiet door assembly when the vehicle door is opened and closed. In another embodiment, the material is a melt-flow material, and upon the application of heat will spread over a surface.

[0006] The present invention further serves to eliminate cleanliness and maintenance issues typically encountered through the use of a pumpable product process or application of "wet" chemical technology in either a pre-assembly stamping facility or a vehicle assembly plant since the anti-vibration damping material can be extruded or mini-application bonded onto the door intrusion device prior to paint operation processing. Hence, the present invention can be utilized by either the door intrusion device manufacturer or the vehicle manufacturer and extruded onto the door intrusion device itself for use by the vehicle manufacturer in the final assembly operation.

[0007] In a particular preferred embodiment, the damping material or medium comprises a plurality of pellets or a bead that is extruded along and onto portions of the intrusion device in a solid (though pliable) form in accordance with the teachings of commonly owned U.S. Pat. No. 5,358,397 ("Apparatus For Extruding Flowable Materials"), hereby expressly incorporated by reference, such type of apparatus being referred to herein as a "min-applicator." A preferred mini-applicator is an extrude-in-place device suitable for extrusion with or without robotic assistance, and which may be portable or remain stationary in a predetermined location. The use of a mini-applicator advantageously allows extrusion of meltable plastic materials of various section sizes or shapes directly at production or assembly lines. The material or medium is at least partially coated with an active polymer having damping characteristics or other heat activated polymer, (e.g., a formable hot melt adhesive based polymer or an expandable structural foam, examples of which include olefinic polymers, vinyl polymers, polyamides, EVA's, thermoplastic adhesives, thermoplastic rubber-containing polymers, epoxies, urethanes or the like). The pellet then expands and bonds to the intrusion device and the body panel when exposed to the e-coat process as well as other paint operation cycles encountered in a final vehicle assembly facility. In addition, it is contemplated that the present invention may utilize an application of expandable material

directly to a structural member or trim component of an automotive vehicle in an automated or otherwise expedited manufacturing process which may involve heating through traditional methods as well as welding and radiation curable technology or cleaning the selected member or part prior to application to assist in adhesion of the expandable material.

[0008] In a particular non-limiting embodiment, a plurality of pellets comprised of the vibration damping material or medium are transformed from a solid or dry chemical state to a visco-elastic stage through the use of a suitable mini-applicator which processes the pellets at a temperature sufficient to transform the pellets into a visco-elastic elastic material capable of flowing onto the external surface of a intrusion device in a desired consistency, thickness, and pattern.

[0009] The heat application and other shear functions from the mini-applicator allows the material to flow in a uniform shape and manner as it is extruded onto an external surface of the intrusion device, such as a door intrusion beam, where it bonds. Once applied to the external surface of the intrusion device by the mini-applicator and no longer exposed to the heat source emanating from the mini-applicator, the material returns to it solid or dry chemical state and thereby remains disposed in place along the selected portion of the intrusion device. The intrusion device is then mounted within an automotive door assembly or other panel assembly by the vehicle manufacture in accordance with manufacturing techniques that are well known in the art. As the assembly is prepared for final assembly of the vehicle, it is processed through e-coat or other heat-inducing paint operations which result in expansion and bonding of the material from the intrusion device to either or both of the outer panel or the inner panel of the selected automotive closure panel, such as a door frame assembly having an inner door panel and an outer door panel, where it cures and remains in place. It is contemplated that the material expands from the external surface of the intrusion device and cross-links to the substrates, which can comprise either of both of a door inner panel and the door outer panel, thereby serving to reduce the noise and vibration emanating from the door assembly. Although the preferred embodiment discloses the material essentially chemically cross-linking from the external surface of an intrusion device, such as a door intrusion beam, into contact with the door outer panel, it will be appreciated that various patterns and applications of the material along the intrusion device would allow the material to expand and chemically cross-link with either or both of the door inner panel and door outer panel as well as any other substrate that may be utilized or encountered in a door assembly or other application which would facilitate either passenger of cargo access to a vehicle.

[0010] In one embodiment the vibration reducing medium is extruded-in-place onto an intrusion device in a continuous or non-continuous extrusion adjacent to one or more inner walls defining a cavity within an automotive door assembly. The vibration reducing medium is activated to accomplish transformation (e.g., expansion or flow) of the active polymer or polymer within the cavity after the door assembly is mounted onto the vehicle and the vehicle is exposed to heat as it is processed through the e-coat coat and paint operation cycles of a final automotive assembly plant, which is well known in the art. The resulting structure includes a wall or expansive extrusion that is coated over at least a portion of its surface with the vibration reducing medium acting to reduce vibration during transport and during functional operation of the door assembly. It will be appreciated that a preferred vibration reduction medium would consist of a damping material comprising a number of chemical formulations including, but not limited to, metal (such as steel, aluminum, etc.), rubber (such as a butyl or isobutylene polymer, copolymer, or similar elastomer having good damping characteristics), and plastic polymer chemistry (ideally material that would remain rigid at temperatures generally encountered by an automotive body skin during operation of the vehicle, for example −40° C. to 190° C.

## DESCRIPTION OF THE DRAWINGS

[0011] The features and inventive aspects of the present invention will become more apparent upon reading the following detailed description, claims, and drawings, of which the following is a brief description:

[0012] **FIG. 1** is a cutaway plan view of a vehicle door assembly with a vibration reducing material extruded-in-place with continuous extrusion in accordance with the present invention prior to activation of the material.

[0013] **FIG. 2** is a cutaway plan view of a vehicle door assembly with a vibration reducing material extruded-in-place with non-continuous extrusion in accordance with the present invention prior to activation of the material.

[0014] **FIG. 3** is a cutaway plan view of a vehicle door assembly utilizing the vibration reducing material of the present invention applied to selected portions of the door frame assembly, including the belt-line reinforcement member.

## DESCRIPTION OF PREFERRED EMBODIMENT

[0015] **FIG. 1** illustrates an example of an automotive door frame assembly **10** typically encountered in the manufacture of automotive vehicles which includes a door intrusion device **12**. As will be appreciated, it is common for such structures to include a plurality of hollow-portioned panel members that are joined and shaped to define the door inner panel **14**, within which there are cavities. As will be recognized, examples of a suitable door frame assembly **10** may include cargo doors, lift gates, hatchbacks, sliding doors, easy access third doors, door handles, locks, window assemblies or other vehicle doors and door components, sub-frame construction, or the like. One such structure in **FIG. 1**, for purposes of illustration (without limitation) includes a door intrusion device **12** which may be in the form of a door intrusion beam. Although the present invention may be used in other portions of a door frame assembly **10** that do not require the presence of a door intrusion device **12** as well as other automotive closure panel assemblies other than doors, the intrusion device **12** is typically comprised of metal (e.g., steel, aluminum, magnesium based, or the like) and may be cold stamped, hot stamped, roll-formed, a tubular beam, a hollow tubular beam, or a hydroformed section. It is also contemplated that the intrusion device **12** could be formed of composite or other high strength polymeric materials depending upon the structural reinforcement required for specific applications of the present invention.

[0016] As stated, it is contemplated that a variety of automotive closure panel applications may be treated in

accordance with the present invention. In **FIG. 1** there is shown a portion of the frame assembly **10** that comprises an intrusion device **12** which bridges the assembly **10** at a first end **16** and a second end **17**, the frame **10** assembly thereby defining the door panel compartment. As illustrated in the cutaway view of **FIG. 1**, the door intrusion device **12** is generally tubular and assists in the reinforcement of the assembly **10** with suitable cross sectional configuration or reinforcements depending upon the size or configuration of the particular application. The intrusion device **12** itself might be hollow and further reinforced, using technology such as that disclosed in U.S. Pat. Nos. 4,922,596, 4,978,562, 5,124,186, and 5,884,960 and commonly owned, co-pending U.S. application Ser. Nos. 09/502,686 filed Feb. 11, 2000 and Ser. No. 09/524,961 filed Mar. 14, 2000, all of which are expressly incorporated by reference.

**[0017]** Vibration reduction of the assembly and door intrusion device **12** is accomplished according to the present invention by an extrusion-in-place or mini-extrusion application of an appropriate pattern **18** of a vibration reduction material **20** of the type discussed herein disposed along either or both of the intrusion device **12** or other selected portion of the door frame assembly **10** such as the belt-line reinforcement member **22** which is formed between the assembly and a corresponding window structure or other portion of the assembly **10** suitable for application of the material **20**. The material **20** is applied over at least a portion of the intrusion device **12** or belt-line **22** in accordance with the extrusion techniques, apparatus, and methods set forth in commonly assigned U.S. Pat. No. 5,358,397, incorporated by reference. It will also be appreciated that the material **20** may comprise pellets extruded along the intrusion device **12** and/or the belt-line **22** in a variety of continuous and non-continuous patterns. In this regard, it is contemplated that technology disclosed in co-pending U.S. application Ser. No. 09/631,21 for a Sound Absorption System For Automotive Vehicles, incorporated by reference, may be employed in the present invention. **FIG. 1** illustrates an example of this by showing a continuously extruded pattern **18** of the material **20** uniformly extruded along the intrusion device **12**. The vibration reduction material **20** preferably is fixedly secured to at least one portion of the intrusion device **12** by one of its own external surfaces. Accordingly, it is preferred that the vibration reduction material **20** is a polymeric foam that includes a bonding component, which maintains it in place on the external surface of the intrusion device **12**, and thereafter, upon heat activation maintains its adhesion to the intrusion device **12** but expands to form a foam within the hollow cavity between the door inner panel and the outer panel of the selected frame assembly **10**. Thus, preferably the vibration reduction material **20** is a heat-activated material having an adhesive component.

**[0018]** Though other heat-activated materials are possible, a preferred heat activated material is an expandable or flowable polymeric formulation, and preferably one that is activate to foam, flow or otherwise change states when exposed to the heating operation of a typical automotive final assembly painting operation. A particularly preferred material is an active polymer formulated in pellet form with each pellet typically 1-20 mm in diameter and generally, but not necessarily, spherical in shape to facilitate the flow of such pellets through the mini-applicator more fully disclosed in commonly-owned U.S. Pat. No. 5,358,397 ("Apparatus For Extruding Flowable Materials"), incorporated by reference and other olefinic polymer-based acoustic foams, and more particularly an ethylene based polymer. For example, without limitation, in one embodiment, the polymeric foam is based on ethylene copolymer or terpolymer that may possess an alpha-olefin. As a copolymer or terpolymer, the polymer is composed of two or three different monomers, i.e., small molecules with high chemical reactivity that are capable of linking up with similar molecules. Examples of particularly preferred polymers include ethylene vinyl acetate, EPDM, or a mixture thereof. Without limitation, other examples of preferred foam formulation that are commercially available include polymer-based material commercially available from L&L Products, Inc. of Romeo, Mich., under the designations as L-2105, L-2100, L-7005 or L-2018, L-7101, L-7102, L-2411, L-2412, L-4141, etc. and may comprise either open or closed cell polymeric base material

**[0019]** A number of other suitable materials are known in the art and may also be used for vibration reduction. One such foam preferably includes a polymeric base material, such as an ethylene-based polymer which, when compounded with appropriate ingredients (typically a blowing and curing agent), expands and cures in a reliable and predicable manner upon the application of heat or the occurrence of a particular ambient condition. From a chemical standpoint for a thermally activated material, the vibration reducing foam is usually initially processed as a flowable thermoplastic material before curing. It will cross-link upon curing, which makes the material resistant of further flow or change of final shape.

**[0020]** One advantage of the preferred vibration reduction material **20** is that the preferred material can be processed in several ways, thereby affording substantial design and production flexibility. For instance, without limitation, the preferred materials can be processed by extrusion techniques discussed herein, injection molding, compression molding, or with a mini-applicator discussed herein. This enables the formation and creation of vibration reduction shaping that exceed the capability and maintenance/cleanliness issues of most prior art materials, which comprise "wet" chemistry compositions. In one preferred embodiment, the material **20** or pellet or even a plurality of pellets (in its uncured state) is generally dry or relatively free of tack to the touch. In another embodiment, the material **20** is applied to the intrusion device **12** through a robotic extrusion process, which serves to minimize the maintenance of wet or tacky mediums and further functions to reduce labor demand on the vehicle manufacturer.

**[0021]** In a particular non-limiting embodiment, the material **20** is applied to the intrusion device **12** through the use of a mini-applicator which applies heat and shear to the material **20** in accordance with the teachings of commonly-owned U.S. Pat. No. 5,358,397 ("Apparatus For Extruding Flowable Materials"), which, in turn, transforms the material **20** consisting of a plurality of pellets from a solid or dry chemical state to a visco-elastic state inside the mini-applicator for application of the material **20** to the desired surface in a desired pattern or consistency, namely an external surface of an intrusion device **12** generally found in automotive vehicles, such as a door intrusion beam.

**[0022]** It is contemplated that the mini-applicator prepares the material **20** into a visco-elastic state which can easily and

uniformly be applied to an exterior surface of the intrusion device 12 in a relatively clean manner where it hardens and bonds. It will be appreciated that the material 20 can be applied to the intrusion device 12 in a uniform shape, thickness, or consistency which could comprise a continuous flow, a non-continuous flow, a pattern application, and even a ribbed design depending upon the particular application and sizing found between the related intrusion device 12 and the inner and outer panels of the chosen automotive panel assembly. Once the mini-applicator applies the material 20 to the intrusion device 12 in the desired shape and pattern, the material 20 cools at the ambient temperature found in the manufacturing facility which allows the material 20 to return to its original solid or dry chemical state thereby bonding and adhering the material 20 to the external surface of the intrusion device 12. The intrusion device 12 is then place mounted onto-the door assembly 10 prior to assembly of the vehicle by the vehicle manufacturer. The door assembly 10 is then integrated into the vehicle for application of the e-coat process as well as other paint operation cycles commonly found in an automotive manufacturing facility. These and paint operating cycles generally involve exposure to heat through cure ovens which activate the material 20 and allow it to expand, thereby chemically cross-linking the material 20 on the external surface of the intrusion device 12 to either or both of the inner door panel or the outer door panel thereby providing a walled or expansive structure which serves to reduce vibration and noise during transport of the vehicle and operation of the door.

[0023] While the preferred materials for fabricating the vibration reduction material have been disclosed, the material 20 can be formed of other materials (e.g., foams regarded in the art as structural foams) provided that the material selected is heat-activated or otherwise activated by an ambient condition (e.g. moisture, pressure, time or the like) and cures in a predictable and reliable manner under appropriate conditions for the selected application. One such material is the polymeric based resin disclosed in commonly owned, co-pending U.S. patent application Ser. No. 09/268.810 (fied Mar. 8, 1999), the teachings of which are incorporated herein by reference.

[0024] Some other possible materials include, but are not limited to, polyolefin materials, copolymers and terpolymers with at least one monomer type an alpha-olefin, phenol/formaldehyde materials, phenoxy materials, and polyurethane. See also, U.S. Pat. Nos. 5,266,133; 5,766,719; 5,755,486; 5,575,526; 5,932,680; and WO 00/27920 (PCT/US 99/24795) (all of which are expressly incorporated by reference). Examples of suitable melt flow materials include, without limitation, formulations found in a commonly owned co-pending application for a Paintable Seal System filed Aug. 7, 2000, hereby incorporated by reference. In general, the desired characteristics of the resulting material include relatively low glass transition point, and good corrosion resistance properties. In this manner, the material does not generally interfere with the materials systems employed by automobile manufacturers. Moreover, it will withstand the processing conditions typically encountered in the manufacture of a vehicle, such as the e-coat priming, cleaning and degreasing and other coating processes, as well as the painting operations encountered in final vehicle assembly.

[0025] In this regard, in applications where a heat activated, thermally expanding material is employed as the vibration reduction material, a consideration involved with the selection and formulation of the material is the temperature at which a material reaction or expansion, and possibly curing, will take place. For instance, in most applications, it is undesirable for the material 20 to be reactive at room temperature or otherwise at the ambient temperature in a production line environment since, in one embodiment, the material 20 is extruded onto the intrusion device by a supplier and then shipped to the vehicle manufacturer as an integrated product. More typically, the material 20 becomes reactive at higher processing temperatures, such as those encountered in an automobile assembly plant, when the material 20 is processed along with the vehicle components at elevated temperatures or at higher applied energy levels, e.g., during e-coat preparation steps and other paint cycles. While temperatures encountered in an automobile e-coat operation may be in the range of about 145° C. to about 210° C. (about 300° F. to 400° F.), primer, filler and paint shop applications are commonly about 93.33° C. (about 200° F.) or higher. The material is thus operative throughout these ranges. If needed, blowing agent activators can be incorporated into the composition to cause expansion at different temperatures outside the above ranges.

[0026] Generally, suitable vibration reduction materials have a range of expansion ranging from approximately 0 to over 1000 percent. The level of expansion of the vibration reduction material 20 may be increased to as high as 1500 percent or more. The material may be expandable to a degree (or otherwise situated on a surface) so that individual nodes remain separated from one another upon expansion, or they may contact one another (either leaving interstitial spaces or not).

[0027] In another embodiment, the vibration reduction material is provided in an encapsulated or partially encapsulated form, which may comprise a pellet, which includes an expandable foamable material, encapsulated or partially encapsulated in an adhesive shell. An example of one such system is disclosed in commonly owned, co-pending U.S. application Ser. No. 09/524,298 ("Expandable Pre-Formed Plug"), hereby incorporated by reference.

[0028] Moreover, the vibration reduction material may include a melt-flowable material such as that disclosed in U.S. Pat. No. 6,030,701 (expressly incorporated by reference).

[0029] Referring again to **FIG. 1**, there is shown one example of a pattern 18 for the vibration reduction material 20 applied to an external surface of an intrusion device 12 prior to heat activation or foaming wherein the material 20 is continuously extruded. **FIG. 2** illustrates a non-continuous pattern 18 of the material 20 achieved by non-continuous extrusion. **FIG. 3** illustrates the placement of the vibration reduction material along selected portions of the door frame assembly 10 which can include the belt line reinforcement 22 or other visible or exterior portions of an automotive vehicle. The skilled artisan will appreciate that the displacement pattern of the material 20 shown in FIGS. 1-3 are non-limiting examples of many patterns that may be employed. It is contemplated that the material, after expansion, may contain a plurality of nodes which are generally disposed in a random pattern and are generally suitable for

the absorption of vibrations and other sound frequencies emanating from the door assembly or otherwise generated by the vehicle or its components including road induced noise and absorb the same. In one preferred embodiment, such patterns and the selection of the material is made for achieving generally miniaturized chamber areas, where it is believed that vibrational energy can be dissipated through the vibrational reduction material.

[0030] In addition, as discussed previously, preformed patterns may also be employed such as those made by extruding a sheet (having a flat or contoured surface) and then die cutting it according to a predetermined configuration in accordance with the intrusion device, and applying it thereto, wherein the extrusion may be either continuous, as shown in **FIG. 1**, or non-continuous, as shown in **FIG. 2**.

[0031] The skilled artisan will appreciate that the use of the vibration reduction system disclosed herein is not intended as being limited only to illustrate the door assembly locations shown in **FIG. 1**. The present invention can be used in any location within a door or hatch entry into an automotive vehicle that may or may not utilize an intrusion device **12**. For instance, other reinforced locations are also possible including, but not limited to, sliding side doors, hatchbacks, rear cargo doors, gates, and crew/club cab designs and the like with or without the presence of an intrusion device **12**.

[0032] Moreover, the skilled artisan will appreciate that the vibration reduction system may be employed in combination with or as a component of a conventional sound blocking baffle, or a vehicle structural reinforcement system, such as is disclosed in commonly owned co-pending U.S. application Ser. Nos. 09/524,961 or 09/502,686 (hereby incorporated by reference).

[0033] A number of advantages are realized in accordance with the present invention, including, but not limited to, the ability to manufacture an integrated intrusion device structure ready for delivery and assembly at a vehicle assembly plant without the need for application of pumpable products, wet chemical products, and multiple sets of tools, such as for other prior art.

[0034] The preferred embodiment of the present invention has been disclosed. A person of ordinary skill in the art would realize however, that certain modifications would come within the teachings of this invention. Therefore, the following claims should be studied to determine the true scope and content of the invention.

What is claimed is:

**1**. A system for the absorption of vibration in an automotive closure panel assembly, comprising:

(a) an intrusion device associated with an automotive exterior panel structure; and

(b) an expandable material for absorbing vibration disposed over at least a portion of said intrusion device and in contact with said intrusion device prior to expansion of said expandable material, and with a surface of said panel after expansion of said expandable material.

**2**. The system as claimed in claim 1, wherein said intrusion device has a first end and a second end fixedly attached to an inner portion of said automotive panel structure thereby defining a cavity.

**3**. The system as claimed in claim 1, wherein an external surface of said intrusion device is at least partially coated with said expandable material.

**4**. The system as claimed in claim 1, wherein said expandable material is a heat activated thermoplastic foamable material.

**5**. The system as claimed in claim 4, wherein said expandable material comprises an extruded pellet.

**6**. The system as claimed in claim 1, wherein said intrusion device comprises a door intrusion beam having an exposed surface.

**7**. The system as claimed in claim 6, wherein said exposed surface of said door intrusion beam is suitable for application of said expandable material.

**8**. The system as claimed in claim 1, wherein said intrusion device is comprised of a high strength polymeric material.

**9**. The system as claimed in claim 1, wherein said expandable material is a heat activated expandable polymer foam.

**10**. The system as claimed in claim 1, wherein said expandable material is an expandable ethylene based foam that is generally free of tack to the touch.

**11**. The system as claimed in claim 9, wherein said expandable material is an expandable ethylene based foam that can be activated at a temperature encountered in an automotive vehicle paint operation.

**12**. A vibration damping system for a door assembly of an automotive vehicle, comprising:

(a) an intrusion device suitable for fixed placement within an automotive vehicle having a first end and a second end mounted to the door assembly defining a cavity therein, said intrusion device further having exposed surface portions between said first end and said second end; and

(b) a plurality of nodes of an expandable vibration damping material in bonding contact over at least a portion of said exposed surface portions of said intrusion device.

**13**. The system as claimed in claim 12, wherein said expandable material is a polymer foam.

**14**. The system as claimed in claim 12, wherein said intrusion device is a intrusion device.

**15**. The system as claimed in claim 12, wherein said expandable material is a heat activated expandable polymer foam.

**16**. The system as claimed in claim 12, wherein said expandable material is an expandable polymer foam that is generally free of tack to the touch.

**17**. The system as claimed in claim 12, wherein said expandable material is an expandable ethylene-based foam that can be activated at a temperature encountered in an automotive vehicle paint operation.

**18**. The system as claimed in claim 12, wherein said nodes include a plurality of nodes of different sizes and shape.

**19**. The system as claimed in claim 16, wherein said expandable material is extruded into pellets.

**20**. The system as claimed in claim 16, wherein said expandable material is encapsulated.

**21**. A system for reducing vibration in an automotive door assembly, comprising:

(a) a intrusion device fixed mounted within an automotive door assembly; and

(b) an expandable material for reducing vibration disposed over at least a portion of said intrusion device and in contact with said intrusion device prior to expansion of said expandable material.

22. The system as claimed in claim 21, wherein said intrusion device defines a cavity of an automotive door assembly.

23. The system as claimed in claim 21, wherein said intrusion device is at least partially coated with said expandable material.

24. The system as claimed in claim 21, wherein said expandable material is a heat activated thermoplastic foamable material.

25. The system as claimed in claim 24, wherein said expandable material comprises an extruded pellet.

26. The system as claimed in claim 21, wherein said intrusion device includes an exposed surface.

27. The system as claimed in claim 26, wherein said exposed surface of said intrusion device is suitable for application of said expandable material.

28. The system as claimed in claim 21, wherein said intrusion device is an automotive intrusion beam.

29. The system as claimed in claim 21, wherein said expandable material is a heat activated expandable polymer foam.

30. The system as claimed in claim 21, wherein said expandable material is an expandable ethylene based foam that is generally free of tack to the touch.

31. The system as claimed in claim 29, wherein said expandable material is an expandable ethylene based foam that can be activated at a temperature encountered in an automotive vehicle paint operation.

* * * * *

# EXHIBIT B

US005358397A

# United States Patent [19]

**Ligon et al.**

[11] **Patent Number: 5,358,397**

[45] **Date of Patent: Oct. 25, 1994**

[54] **APPARATUS FOR EXTRUDING FLOWABLE MATERIALS**


[75] Inventors: **Robert M. Ligon; Thomas B. Carter**, both of Phoenix, Ariz.; **Jurg Hauptli**, Romeo, Mich.

[73] Assignee: **L&L Products, Inc.**, Romeo, Mich.



[21] Appl. No.: **60,106**

[22] Filed: **May 10, 1993**

[51] **Int. Cl.**[5] ........................ **B29C 47/92**; B30B 15/26

[52] **U.S. Cl.** ................................ **425/145**; 156/244.11; 156/356; 156/500; 264/177.17; 264/177.19; 264/261; 264/323; 901/6; 901/46; 425/149; 425/162; 425/170; 425/192 R; 425/379.1

[58] **Field of Search** ................ 264/323, 177.1, 177.16, 264/177.17, 177.19, 261; 156/107, 108, 109, 244.11, 500, 356, 367; 425/192 R, 190, 208, 145, 149, 379.1, 162, 170; 118/692; 901/6, 46



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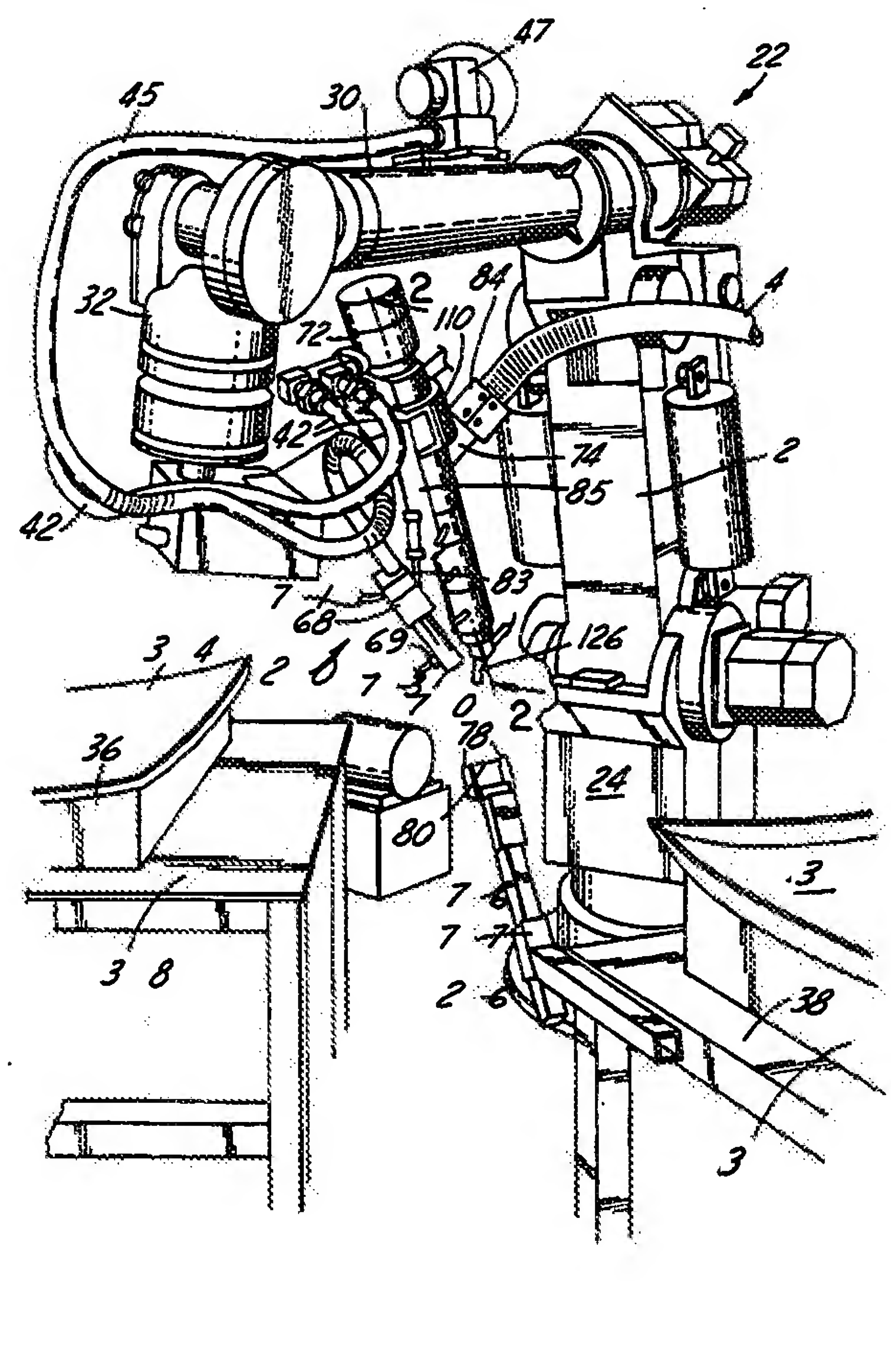
*Primary Examiner*—Jeffery Thurlow
*Attorney, Agent, or Firm*—Dykema Gossett



[57] **ABSTRACT**

A light weight extruder (**20**) is suitable for high production, in-line extrusion of flowable materials with high precision in the placement and control of the extruded material. The extruder uses a high torque hydraulic motor (**72**) to drive a feed screw (**88**) in dispensing highly viscous but flowable material through an extrusion die (**126**) of preselected configuration. A plurality of heating bands (**114–118**) surrounding the barrel (**86**) of the extruder provide precise control over the material temperature at the point of extrusion. In an alternate embodiment, an injection nozzle (**120*a***) is provided with a plurality of independently controllable extrusion dies (**128, 130, 132**). The extruder is sufficiently light and manipulable such that it can be mounted on the end of the arm of a robot (**122**).


**8 Claims, 6 Drawing Sheets**



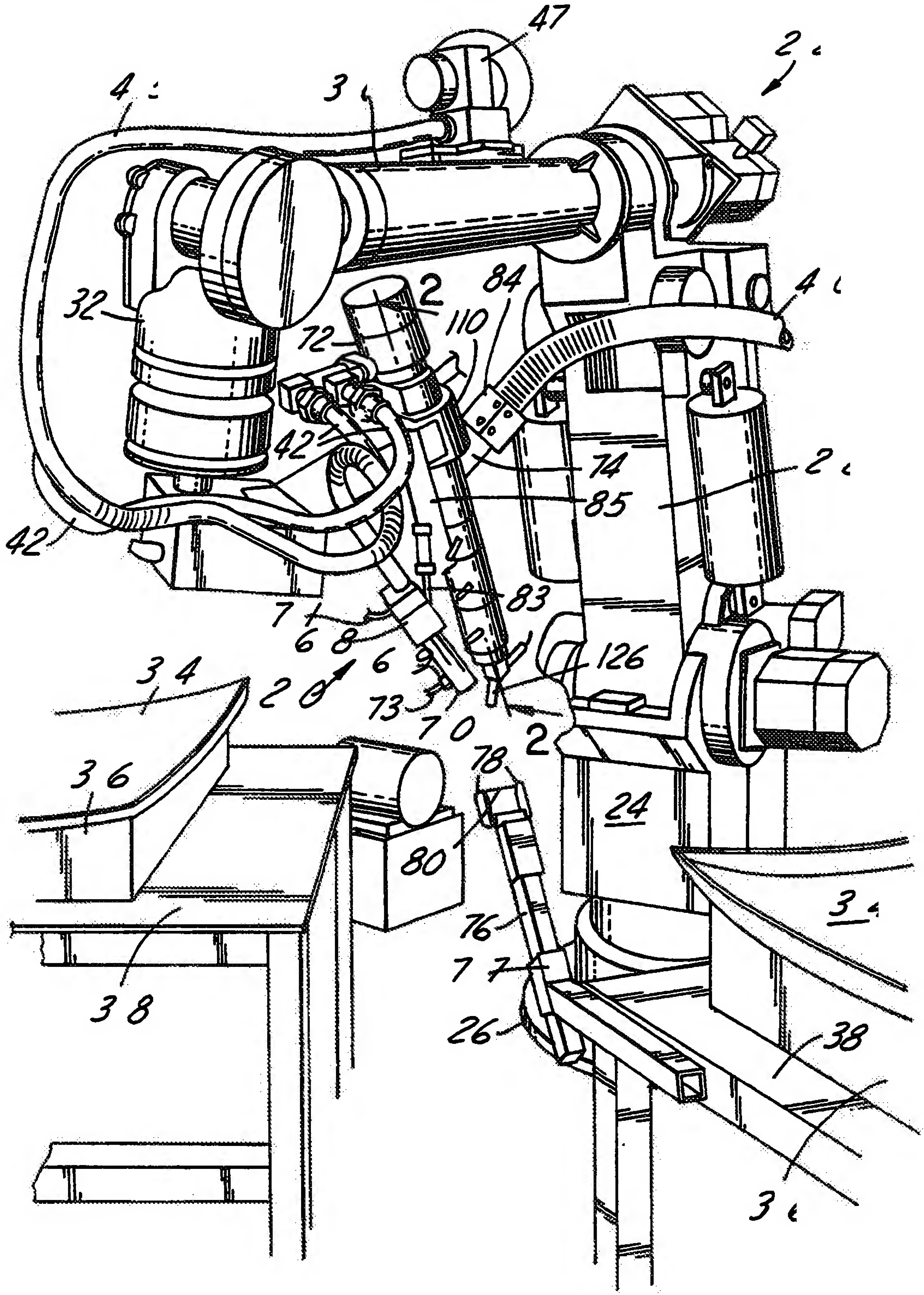
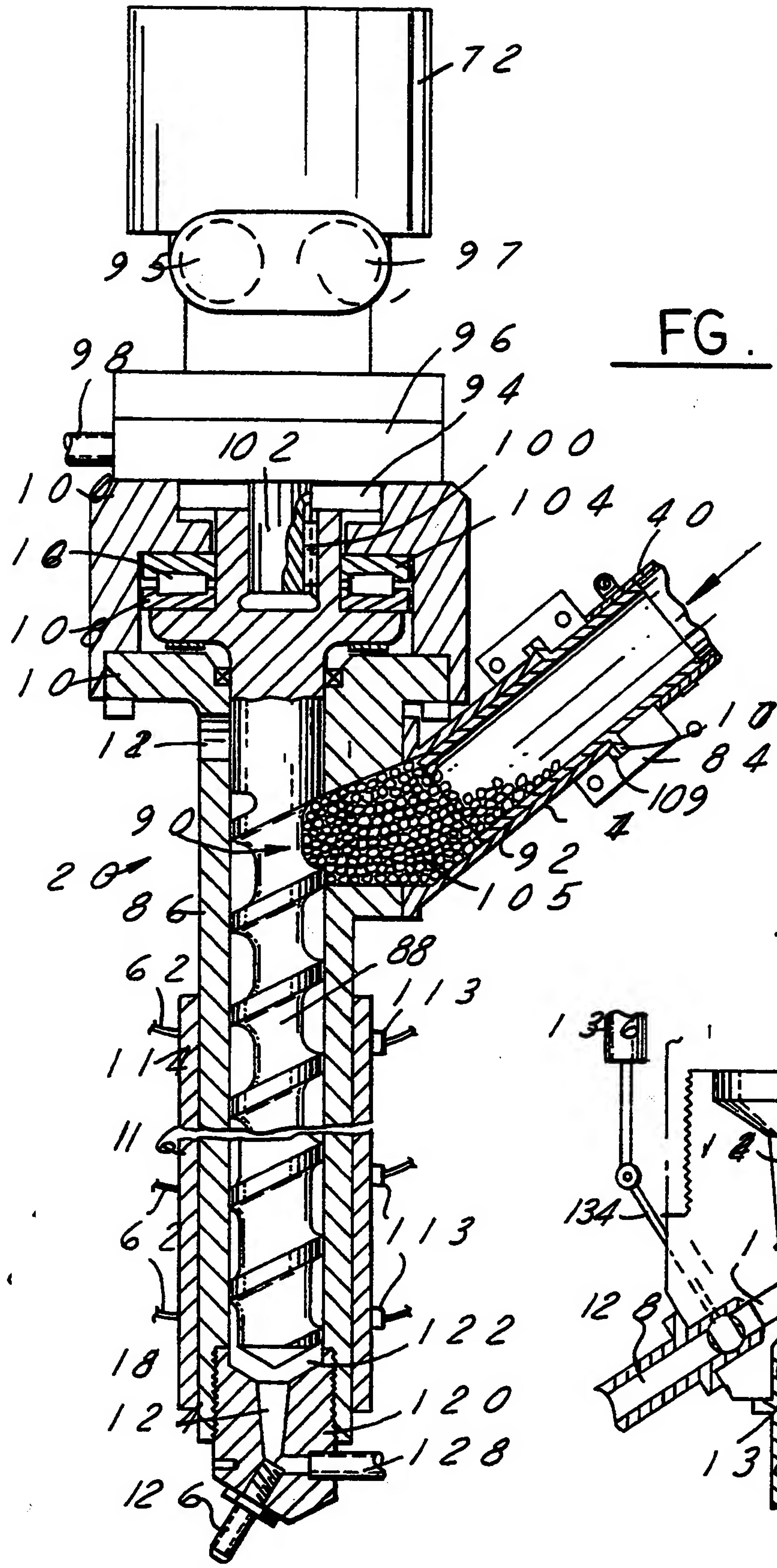



FIG. 1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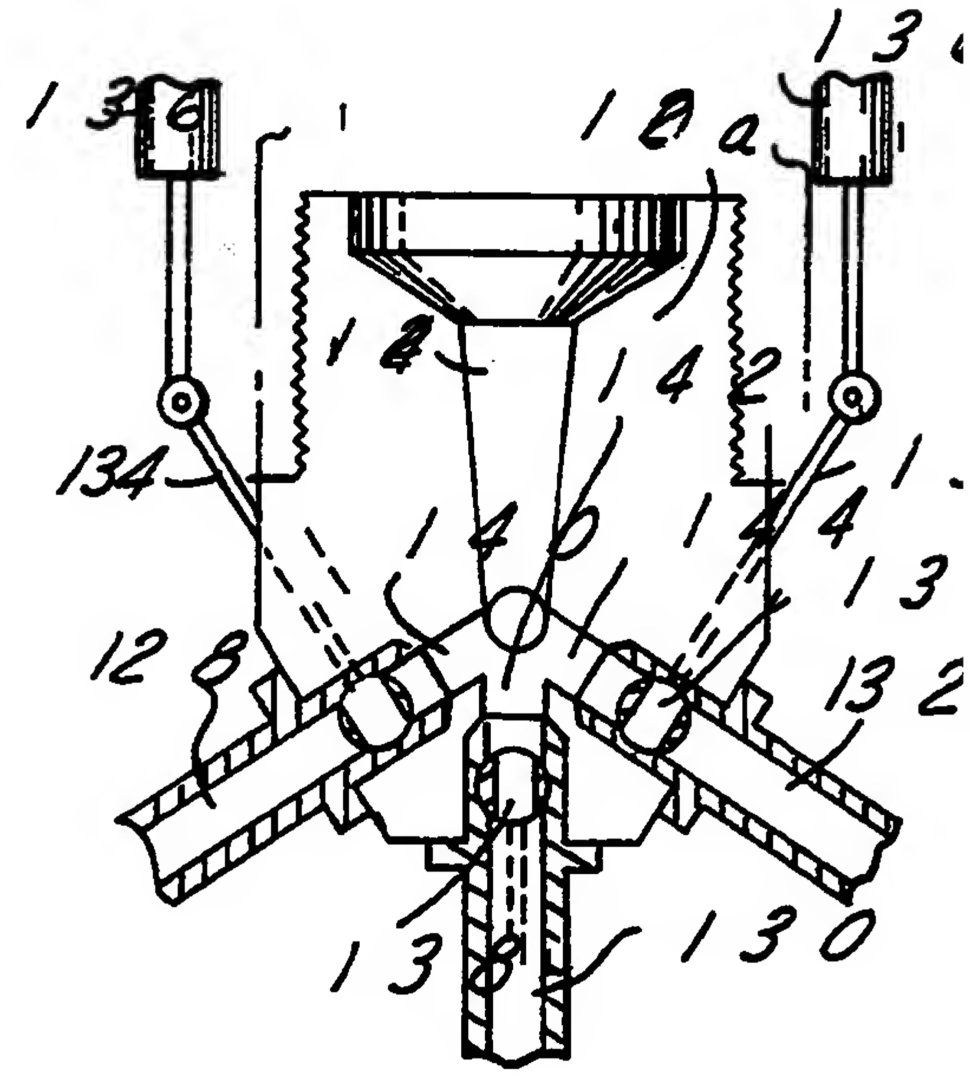
FG. 2

FIG. 8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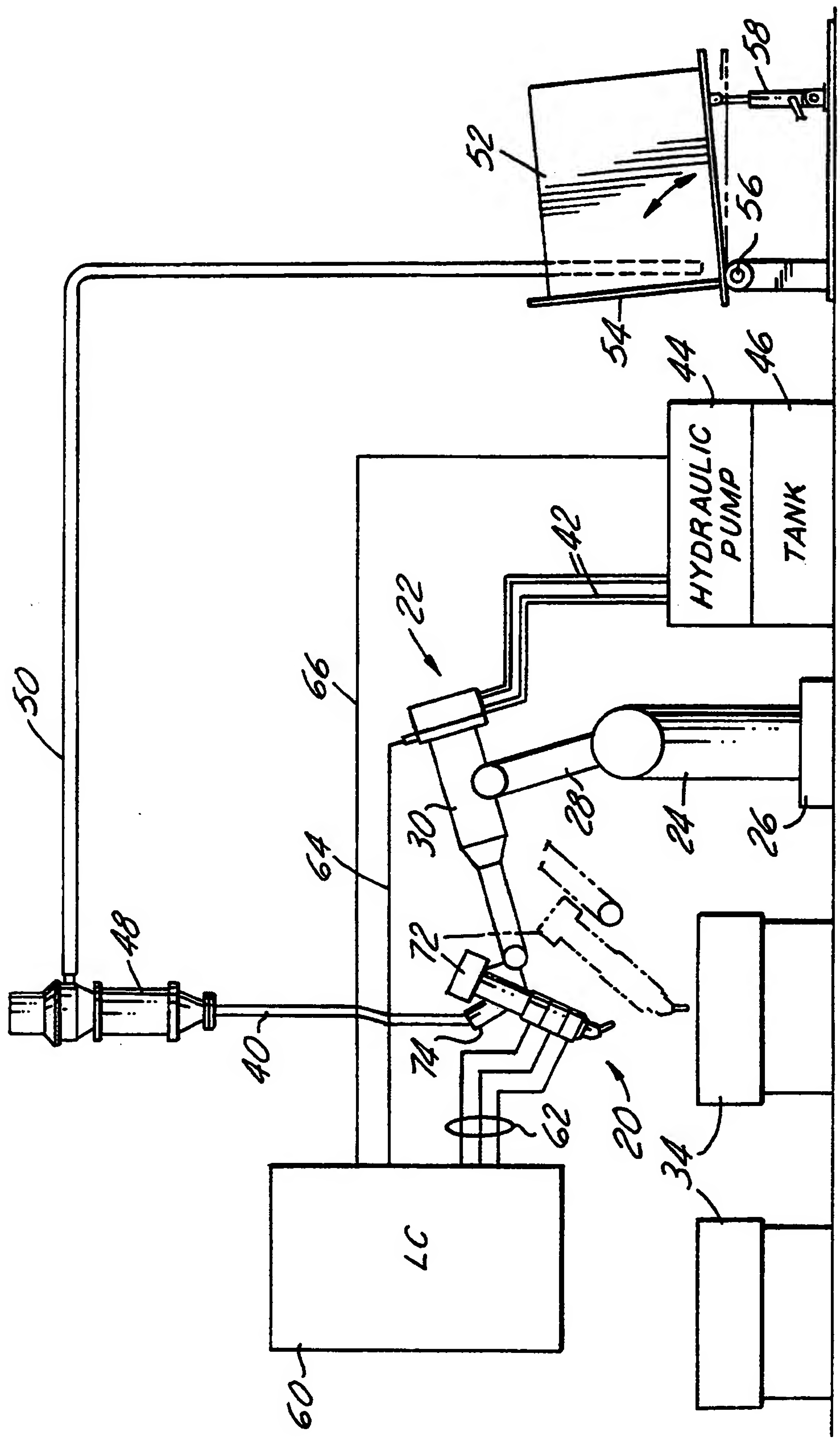

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HYDRAULIC PUMP
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64
72
48
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74
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62
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34
LC
60


FIG.3

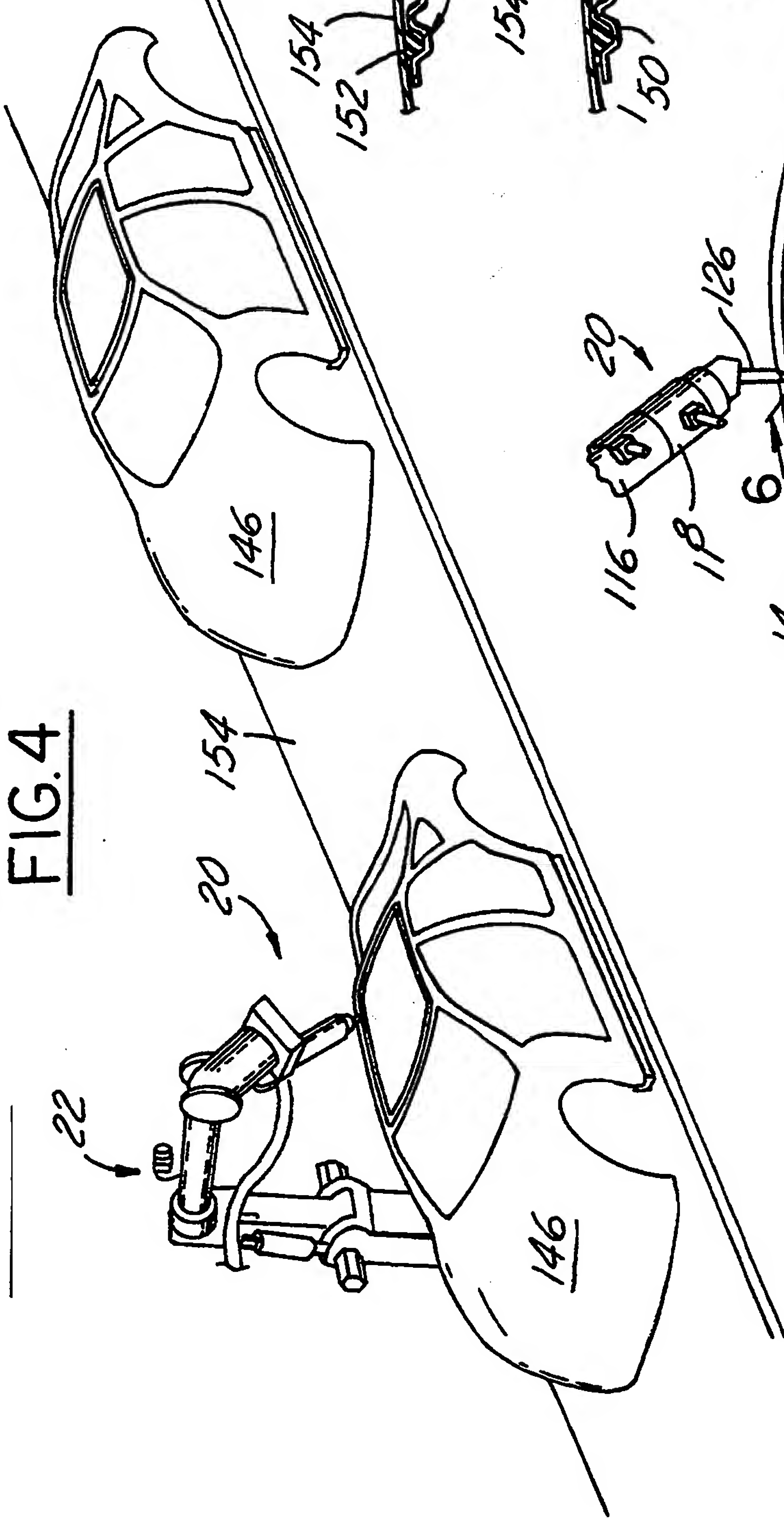



FIG.4

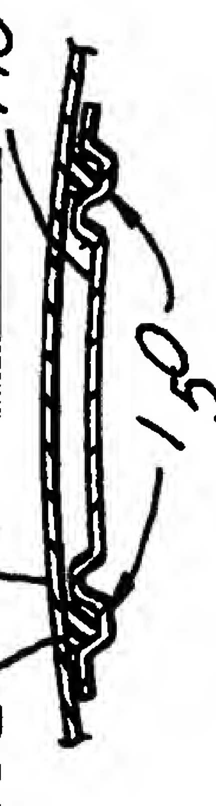



FIG.7a


FIG.7b

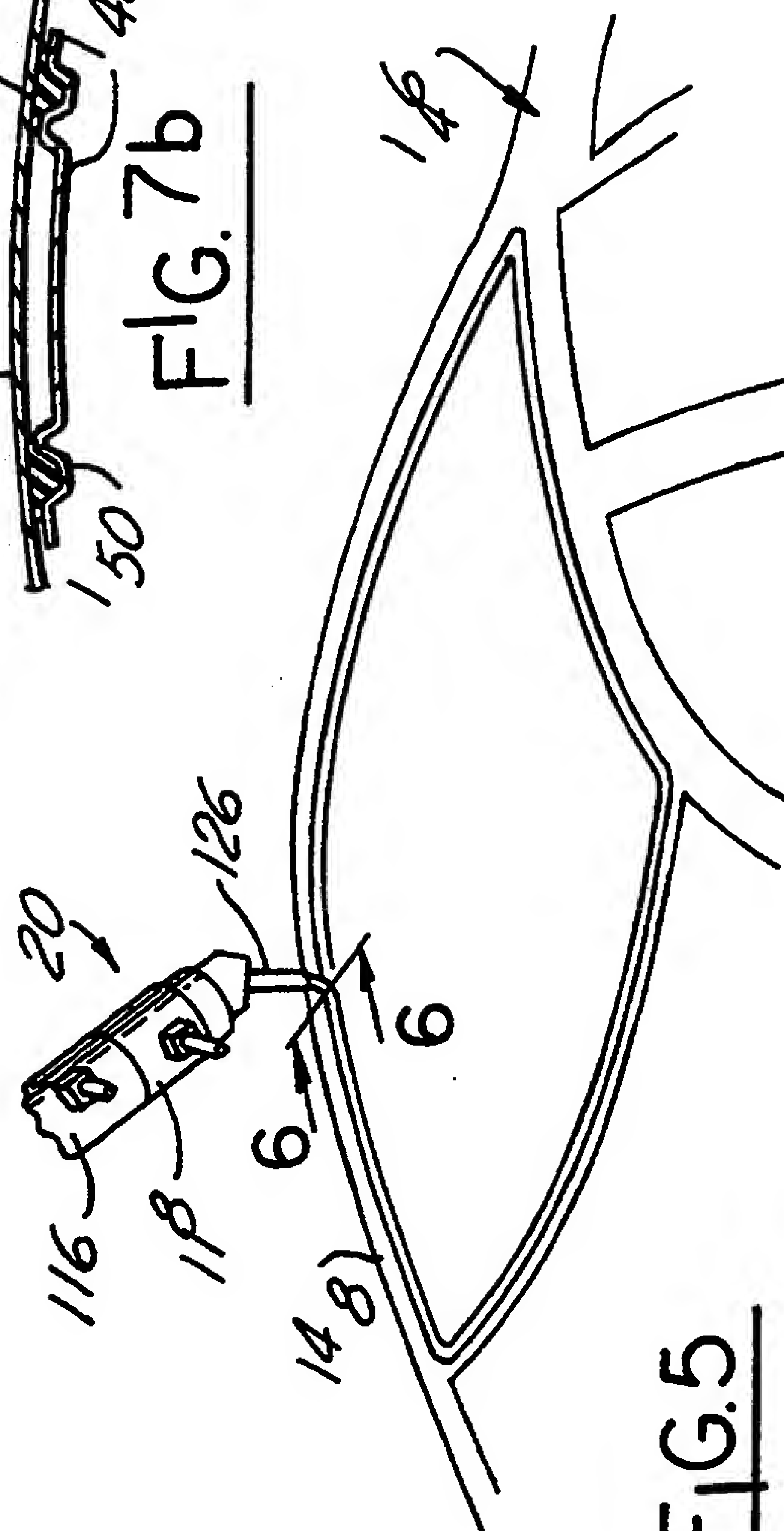



FIG.5

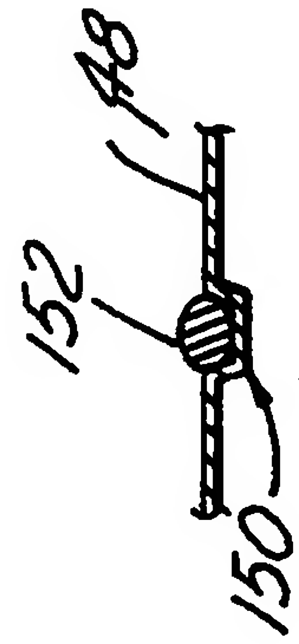



FIG.6

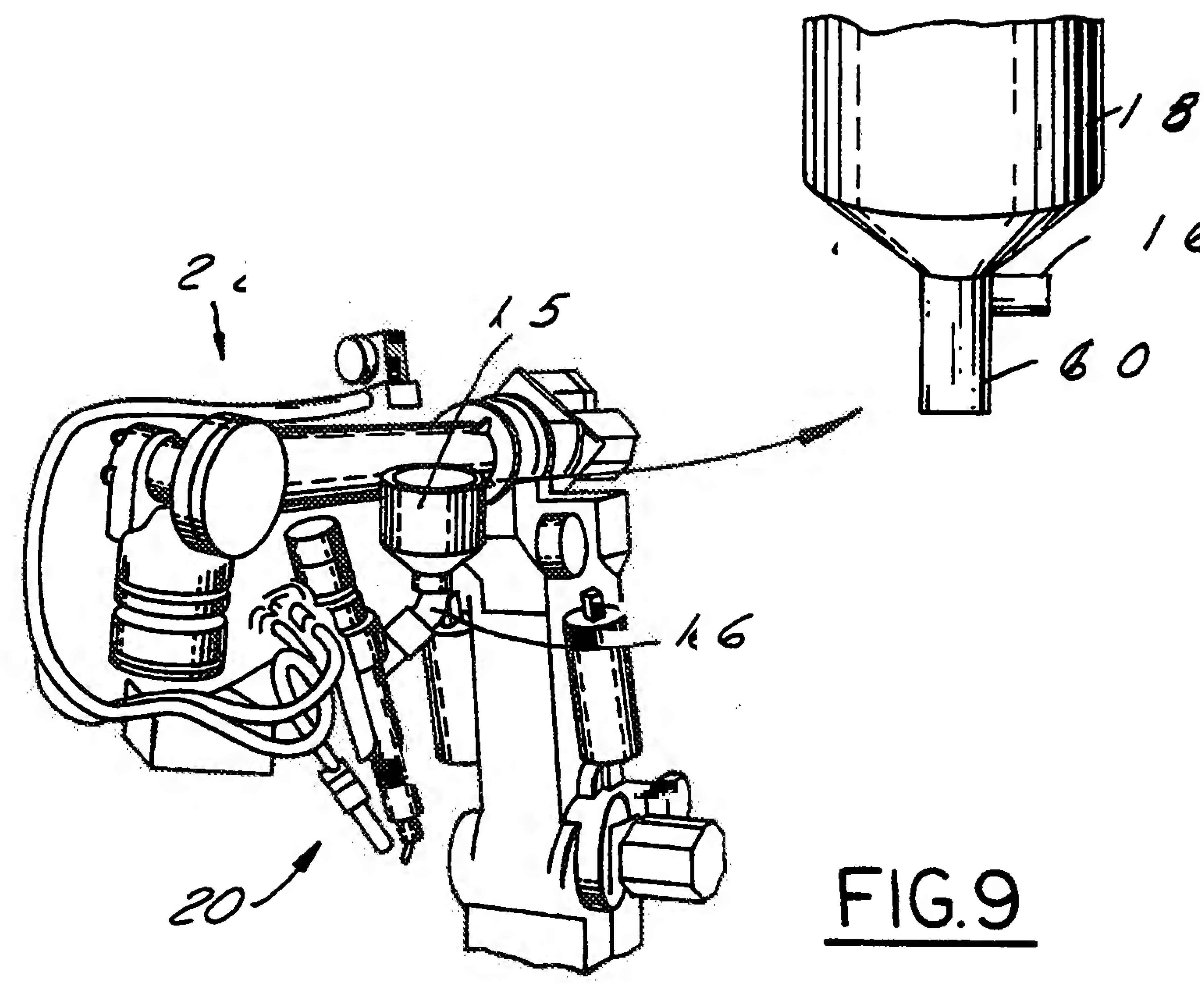
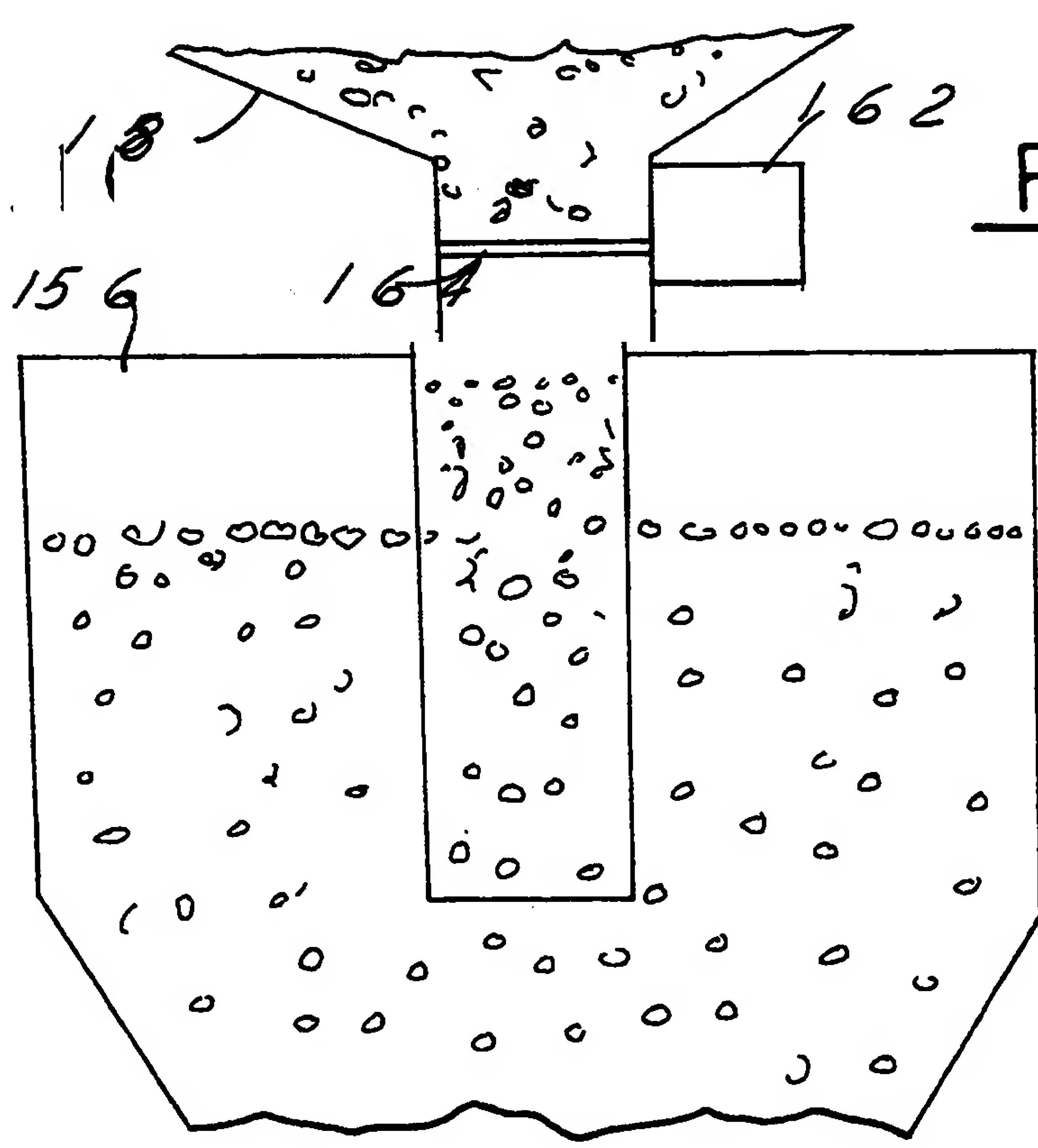



FIG.9




FIG

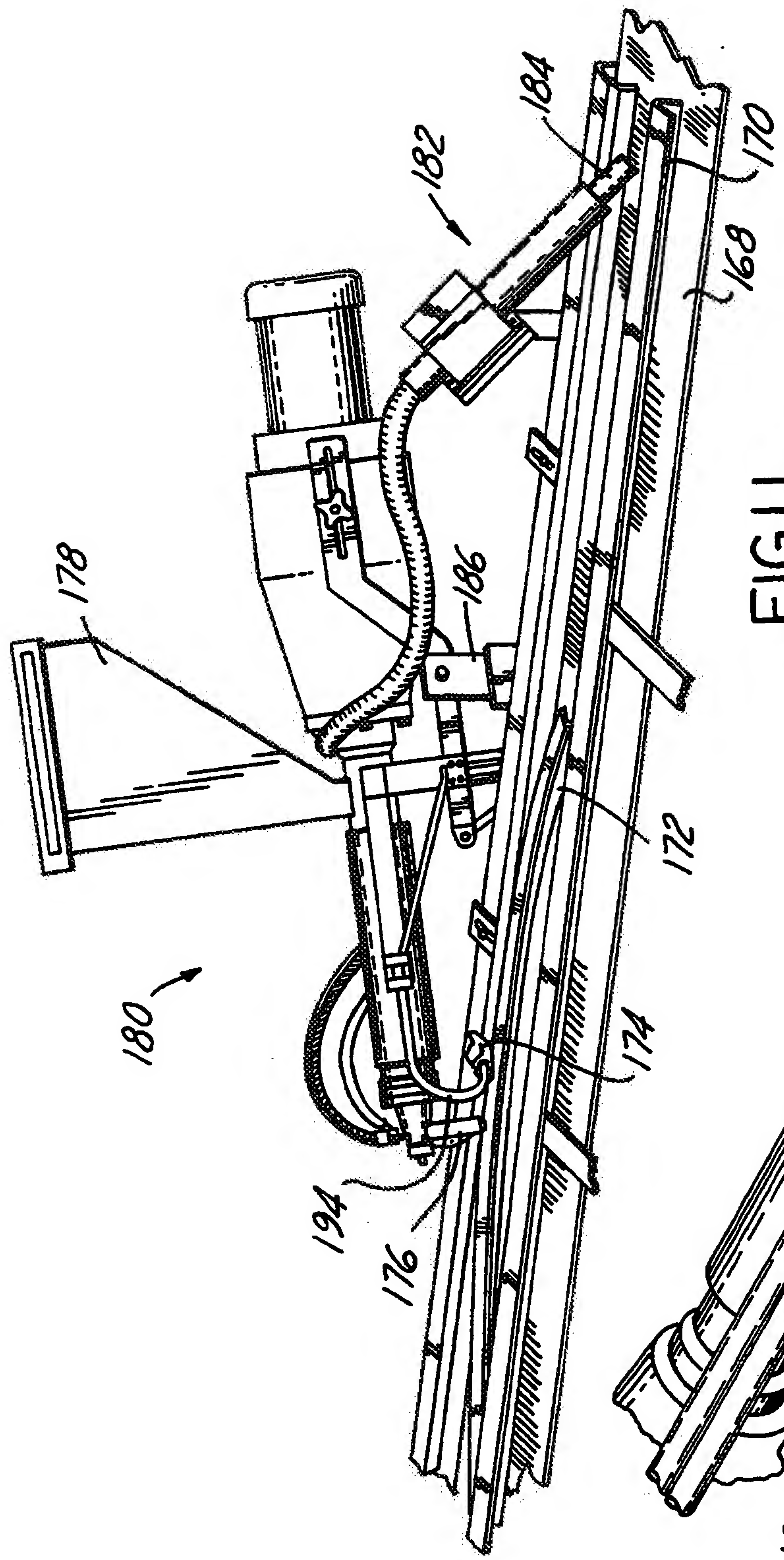



FIG. 11

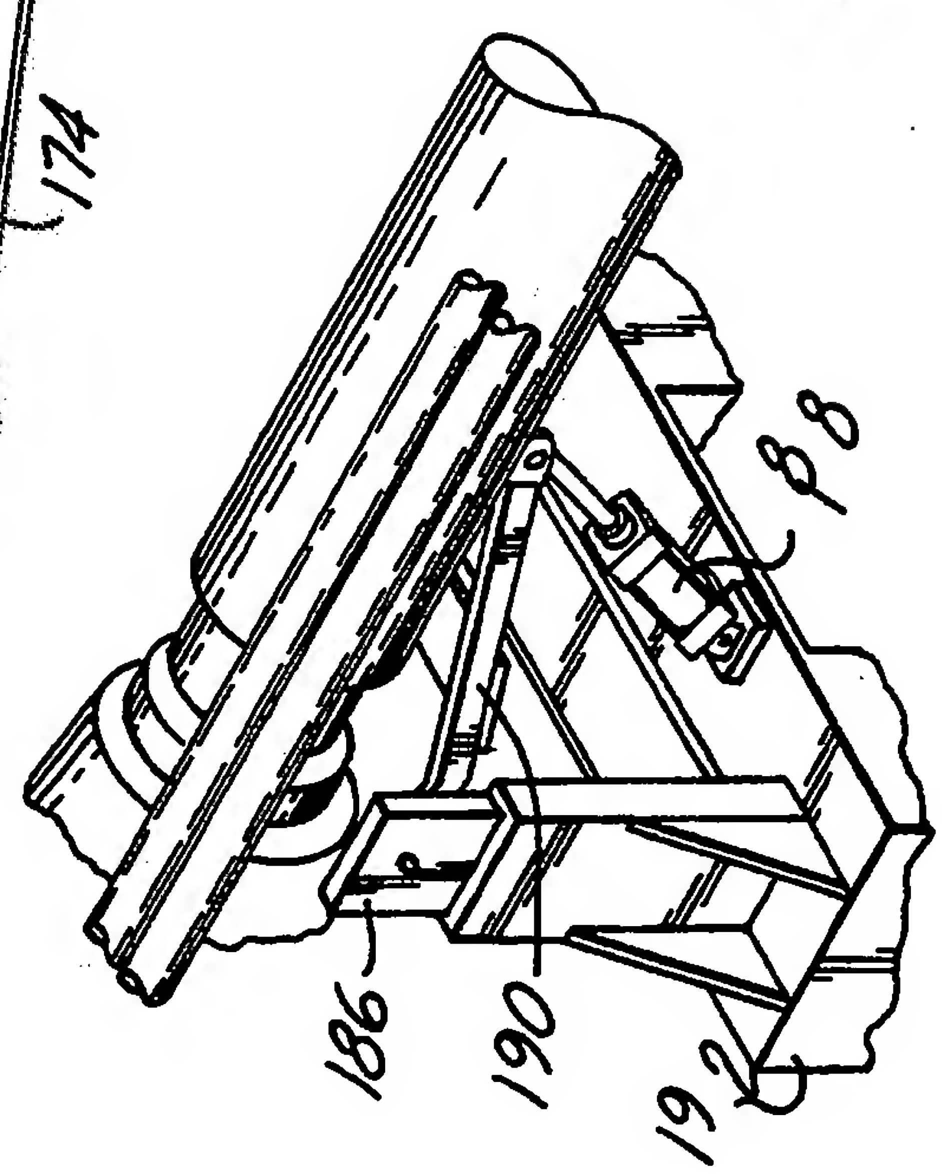



FIG. 12

# APPARATUS FOR EXTRUDING FLOWABLE MATERIALS

## TECHNICAL FIELD

The present invention generally relates to a method and apparatus for extruding flowable materials, and deals more particularly with a system for controllably applying a bead of extruded material in place in precise locations on a part substrate, particularly on-line, in mass production line applications.

## BACKGROUND OF THE INVENTION

Sealants, adhesives and similar flowable or moldable components are often used on various parts of assemblies which are assembled on a moving production line. Such sealants are used, for example between internal mating surfaces of automobile body parts to achieve adhesion, water tight seal and vibration isolation between these parts. Often times, the body parts are formed in a manner to specifically receive the sealants in certain locations; for example, the interior roof panel of an automobile may be formed with one or more channels therein, of various cross-sectional configurations, to receive a bead of sealant which adheres to and forms a seal with the outer roof panel of the automobile. The bead of sealant is preferably applied within the channel such that it initially possesses a cross-section similar to that of the channel but is expandable so that it fills the entire channel and moves into contact with a mating body part to form a proper seal.

In the past, sealants of the type described above have been sometimes applied to the parts on an off-line basis. That is to say that the sealants have been either preformed and/or applied to the parts which are stock piled and later installed into the assembly on the production line.

In some cases, attempts have been made to apply sealants on body parts directly on the assembly line by pumping the sealant from a bulk supply through a fluid line to a nozzle which a production worker manually manipulates to lay a bead of sealant into a predesired location on a body part. On-line pumping of sealants in this manner has not been entirely successful for a number of reasons. First, most "pumpable" sealants do not cure until they are heated when the assembled part is introduced into an oven on the assembly line. This delay in curing is undesirable for a number of reasons. Pumpable type sealants must possess requisite characteristics to allow them to flow through a long feed tube to the production line, yet these same characteristics often reduce the sealers performance in the areas of strength, shock vibration, etc. Also, the equipment needed to pump flowable sealants, and particularly those used to pump hot sealants can result in equipment problems, since those that have quick curing times commence curing (and thus altering their physical characteristics) as they flow through the supply tube to the exit nozzle.

Others in the past have devised extruders of various types which may be considered as portable. However, known portable extruders had been limited in their use to relatively flowable, low viscosity materials which are not suitable as sealants and adhesives in many applications, such as the assembly of automobile body parts. Automobile assembly operations require extremely high performance sealants and adhesives which typically possess extremely high viscosity and very short curing times.



There is therefore a need in the art for a method and apparatus for extruding in-place high viscosity, high performance flowable materials, in place in predetermined locations on a part substrate.

## SUMMARY OF THE INVENTION

The present invention broadly involves a method and related apparatus for extruding flowable materials, particularly those that are highly viscous, into precise locations onto substrates, in a highly repeatable manner. The method and apparatus of the present invention are particularly well-suited for use on automated production lines, as in the manufacture of vehicles for example, where sealants, adhesives and similar high viscosity materials are extruded directly into place on an on-line basis. The apparatus broadly comprises a barrel shaped housing within which there is rotably disposed an extrusion screw driven by a hydraulic motor. Material in solid form such as pellets, for example, is supplied from a remote supply source through a tube to the extruder housing. A plurality of heating bands around the housing progressively heat the solid material as it is compressed by the extrusion screw so that the material melts and is extruded through an extrusion die at a carefully preselected pressure and temperature. The use of a hydraulic motor provides high torque and quick response so that material can be extruded into tight tolerance locations. However, the extruder unit is exceptionally light, allowing it to be mounted on the end of a robotic arm so that it can be easily manipulated for extruding material into place on an on-line basis.

The method of the present invention involves extruding flowable materials into precise locations on an on-line basis, as in assembly line operations.

Therefore, a primary object of the invention is to provide a method and related apparatus for extruding high viscosity, flowable materials in-place, and in preselected locations on part substrates.

Another object of the invention is to provide a method and apparatus as described above which permit extrusion of beads of the flowable material of predetermined cross-section which are precisely extruded into grooves, channels or other areas particularly adapted to receive these beads, and to do so quickly and precisely.

Another object of the present invention is to provide a portable extruder capable of extruding very high viscosity, flowable materials.

A further object of the invention is to provide a portable extrusion machine which is exceptionally light and is easily manipulated such that it may be mounted upon a robot arm or the like.

A further object of the present invention is to provide a method and apparatus as described above which eliminates the need for pumping flowable materials from a bulk source through a long supply tube to an extrusion nozzle.

These, and further objects and advantages of the invention will be made clear or will be become apparent during course of the following description of a preferred embodiment of the present invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which form an integral part of the specification and are to be read in conjunction therewith, and in which like reference numerals are employed to designate identical parts in the various views:

FIG. 1 is a perspective view of the portable extruder forming the preferred embodiment of the present invention, shown mounted on the end of a robotic arm, depicting use of the apparatus to apply extruded materials to parts on an off-line basis;

FIG. 2 is a sectional view of the portable extruder, taking along the line 2—2 in FIG. 1;

FIG. 3 is a diagrammatic view of the portable extruder shown in FIG. 1;

FIG. 4 is a view of the portable extruder of FIG. 1, but shown in relationship to an assembly line for manufacturing automobiles;

FIG. 5 is an enlarged, perspective view of a portion of a vehicle body and the extruder shown in FIG. 4;

FIG. 6 is a cross-sectional view taken along the line 6—6 in FIG. 5;

FIGS. *7a* and *7b* are views similar to FIG. 6 but showing a roof panel having been installed, and depicting the position of the extruded sealant bead respectively before and after expansion thereof;

FIG. 8 is a fragmentary, cross-sectional view of an alternate form of a nozzle for use with the extruder of FIG. 1;

FIG. 9 is a perspective view of an extruder according to the present invention, depicting an alternate form of a material supply system;

FIG. 10 is an enlarged, cross-sectional view of the batch hopper and supply feed tube of the system shown in FIG. 9, immediately after a batch has been dispensed;

FIG. 11 is a perspective view of an alternate form of the extruder of the present invention, shown in relationship to a conveyor line; and

FIG. 12 is a fragmentary rear view of the extruder of FIG. 11.

## DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring first to FIGS. 1, 2 and 3, the present invention broadly relates to a light weight, portable material extruder, generally indicated by the numeral 20 which, in FIGS. 1 and 3 is shown mounted on a robot mechanism 22. The robot 22 comprises a stationarily mounted base 26 upon which there is rotatably mounted a turret 24, along with three pivotally connected arms 28, 30 and 32. The extruder 20 is mounted on the end of arm 32 and thus has freedom of movement about 6 axes.

In FIG. 1, the extruder 20 is operated on an off-line basis to apply extrusions at appropriate locations on stationary parts, such as the roof panels 34 which are mounted on jigs 36 supported on individual tables 38. The extruder 20 is powered by a hydraulic motor 72 which is coupled with a pair of hydraulic lines 42 to a hydraulic pump 44 and related reservoir tank of hydraulic fluid 46. The material extruded by the extruder 20 is supplied from a bin 52 in the form of pellets, granules, particles or the like, depending upon the nature of the material. The supply bin 52 is mounted upon a table 54 which tilts about a pivot point 56 in response to elevation by a pneumatic cylinder 58. Electrically operated vacuum pump 48 draws the solid pellets of material from the supply bin 52 through draw tube 50 to a point elevated above the extruder 20. The pellets are then gravity fed through feed tube 40 into an inlet tube 74 (FIG. 2) of the extruder 20.

In connection with extruding many forms of adhesives and sealers, particularly expandable adhesives, it is quite important to control shear characteristics of the material. In order to control shear, it is important to precisely control the temperature of the material; the application of an inordinate amount of compression to the material can result in heating the material to a level that adversely affects its shear characteristics. The use of a hydraulic motor to drive the extruder allows precise control over the compression characteristics of the extruder. The hydraulic motor 72 provides a large amount of torque and possesses a fast response curve, thus allowing the extrusion to be started and stopped very quickly. This control characteristic is very important in connection with extruding flowable materials into tight tolerance gaps and other locations.

As best seen in FIG. 3, virtually all functions of the extruder 20 and associated robot 22 are controlled by a PLC 60 (programmable logic controller). Electrical control signals are delivered from the PLC 60 via line 66 to the hydraulic pump 44, via line 64 to various servo motors on the robot 22 and via lines 62 to three separate heating elements 114, 116 and 118 surrounding the middle and lower reaches of the cylindrical barrel 86 of the extruder 20.

As best seen in FIG. 1, an air blower 47 mounted on arm 30 of robot 20 delivers air through line 45 to an electrically heated manifold 68 to which there is attached an outlet air nozzle 70. The manifold 68 and a temperature sensor 69 on the end of nozzle 70 are connected to the PLC 60 via lines 71 and 73, respectively. The manifold 68 is pivotably mounted on a rod 83 which is longitudinally adjustable within a threaded mounting flange 85 which is secured to a hub 110 forming part of the extruder 20. By this manner of mounting, the end of the nozzle 70 may be adjusted so as to direct warm air at a desired temperature onto the substrate in close proximity to the point where an extruded bead of material exits an extrusion die 126 and is deposited onto the substrate.

Referring particularly to FIG. 2, the hydraulic motor 72 includes a pair of threaded fluid ports 95, 97 which are adapted to be coupled with the hydraulic lines 42. Hydraulic motor 72 is mounted through a spacer 96 and adapter ring 94 to a cylindrical hub 110. The adapter ring 94 surrounds the output shaft 102 and is received within a cylindrical depreciation within the hub 110.A rotatable output shaft 102 of the motor 72 extends through the hub 96 and into an opening in the hub 110 where it is secured via a key 100 to the upper reaches of feed screw 88. A tach sensor 98 is mounted on the spacer 96 to sense the rotational speed of shaft 102. The upper end of the feed screw 88 is journaled for rotation within the hub by means of a thrust bearing comprising a pair of bearing races 104, 108 and roller bearings 106.

The upper end of the cylindrical barrel 86 includes a cylindrical flange 101 secured by bolts to a circumferentially extending shoulder of the hub 110. A lateral opening 112 in the sidewall of barrel 86 provides pressure relief. An inlet opening 90 in the barrel 86 allows the introduction of solid material pellets 105 into the interior of the barrel 86, at the upper end of the feed screw 88. The inlet feed tube 74 forms a slight dog leg feed path into the opening 90 which may, depending upon the nature of the pellets 105 and the attitude of the extruder 20, become jammed somewhat, from time to time, thereby potentially interrupting constant flow to the feed screw 88. To eliminate this problem a novel, swivel feed tube connection has been provided for coupling the feed tube 40 to the inlet tube 74. This connection comprises an inner, tubular sleeve 92 which extends down into the inlet tube 74 and is secured to the feed tube 40. The inner sleeve 92 includes a circumferential

flange 107 which rotatably bears upon a mating flange 109 on the upper end of inlet tube 74. Flanges 107 and 109 are received within a groove in a collar 84 which is secured to sleeve 92 and has a portion surrounding inlet tube 74. From the description of the foregoing inner connection, it may thus be appreciated that the inner sleeve 92, collar 84 and feed tube 40 rotate independently of the inlet tube 74. By this arrangement, in the event that the pellets 105 of material jam near the bottom of the inlet tube 74, the rotational movement of the feed tube 40, and thus the inner sleeve 92 tends to dislodge the pellets so that they flow freely into the inlet opening 90 so as to smoothly feed into the screw 88. Also, it may be appreciated that the extruder may be moved and manipulated during the extrusion process through many degrees of motion without stressing or otherwise interferring with proper flow of pellets through the feed tube 40, since the feed tube 40 rotates freely upon the extruder 20.

As indicated earlier, the medial and lower reaches of the barrel 86 have mounted therearound band shaped heating elements 114 which are controlled by the PLC 60. The heating bands 114, 116 and 118 conformally surround the barrel 86 and are provided with temperature sensors 113 to provide temperature feed back information to a display (not shown) and the PLC 60. The lower heating band 118 can be seen to reach virtually to the end of the barrel 86, adjacent the extrusion nozzle 120. The heating bands 114–118 function to melt the pellets 105 into a flowable material which is fed by the screw action of feed screw 88 to an accumulating chamber 122 and thence through a tapered feed passage 124 within nozzle 120 to an extrusion die 126. Extrusion die 126 possesses an extrusion opening therein which has a cross-section conforming to the desired shape of the extruded bead. The extrusion die 126 is threadably received within in the nozzle 120 which in turn is threadably received within a lower threaded opening in barrel 86, concentric with the central axis of feed screw 88. A pressure sensor 128 secured within nozzle 120 delivers signals to the PLC 60 relating to the pressure of the flowable material as it enters the die 126.

In order to assure that a perfect bead emerges from the die 126 at the beginning of an extrusion cycle, it is preferred to wipe off any excess material from the end of the die 126 before such cycle is commenced. For this purpose, as shown in FIG. 1, a wiper may be provided comprising a wiping wire 80 held tauntly between the ends of two arms 78 which are mounted on the end of a rod 76. The rod 76 is slidably adjustable within a holder 77 mounted on the table 38. In order to wipe excess material from the end of the nozzle 126, the robot 22 simply moves the extruder 20 such that the outer end of the die 126 passes across the wire 80 which cuts off the excess material.

Attention is now directed to FIG. 8 which depicts, on a larger scale, an alternate form of nozzle arrangement for the extruder 20, in which a plurality of extrusion dies 128, 130 and 132 are provided. The multiple dies 128–132 may be positioned in the nozzle body 120*a* at any desired position or angle, relative to each other, and may possess die openings which differ in their characteristics (size, cross-sectional configuration, etc.). This permits on-line extrusion of differently configured beads without the need for changing dies or using multiple extruders. The bottom end of the feed passageway 124 delivers flowable material to the dies 128–132 via distribution channels 140, 142 and 144. Flow of the material is selectively controlled to the multiple dies 128–132 by means of valving, herein illustrated as ball valves 138 which are operated by linkage rods 138 operated by any suitable form of motors such as pneumatic cylinders 136.

Attention is now directed to FIGS. 4, 5 and 6 which depict the extruder 20 adapted for use in an in-line extrusion application for automated assembly of vehicles on a production line. Vehicle bodies 146 on a moving production line 154 pass by a sealant application station comprising the previously described extruder 20 mounted on the end of a robot 22. Under programmed control of the PLC 60 (FIG. 3) the extruder 20 automatically extrudes a bead 152 of material into a channel 150 formed in the roof surface 148 of each vehicle 146. By virtue of the precise control of material flow afforded by the use of the hydraulic motor 72, and the exceptionally light weight of the extruder 20 owing to its construction which allows it to be placed on the end of a robotic arm, a precisely configured bead of sealant may be introduced at the proper location within the channel 150 around the entire periphery of the roof surface 148, while the vehicle 146 moves down the assembly line.

As previously stated, it is quite important that the sealant bead 152 exit from the extruder 20 at the proper temperature, with proper flow characteristics and with a desired cross-sectional configuration so that the sealant bead 152 will properly perform its function. These material characteristics are particularly important in various applications, as for example where sealant material is used which later expands after curing or the application of heat, to fill voids between body parts. For example, FIG. 7*a* depicts the roof surface 148 immediately after a roof panel 154 has been installed in overlying relationship on the vehicle 146; a slight gap forming a void is present between the roof panel 154 and roof surface 148. FIG. 7*b* shows the relationship of these components after the bead of sealant has been expanded through curing and/or the application of heat to fill the void between the body parts. The control overflow characteristics of the sealant material is achieved in a very precise manner, for several reasons. First, as stated before, the use of a hydraulic motor 72 results in the provision of a very high level of torque to the feed screw 88, yet the weight of the hydraulic motor 72 is not so great as to preclude mounting the extruder 20 on a robot arm. The tachometer sensor 98 precisely senses the rotational rate of the feed screw 88, and thus provides immediate feedback information which allows the PLC 60 to control the hydraulic motor 72 accordingly. Also, the heating bands 114–118, along with temperature sensors 113 envelop the sealant material to define separately controllable heating zones and control the final temperature quite precisely as the material exits the extrusion die 126. The exact flow rate of sealant material exiting the die 126 is further controlled as result of the provision of the pressure sensor 128 which provides feedback information to the PLC 60 relative to the pressure of the sealant material immediately before it is extruded, which in turn is directly related to flow rate. The unique rotatable connection of the feed tube 40 to the extruder 20 also assures constant, controllable flow rate in that temporary interruption or diminution of material feed is eliminated. Finally, the provision of a flow of precisely directed hot air emanating from the heat nozzle 70 allows the substrate to be pre-heated, thereby better conditioning the extruded material to absorb oils and the like from the substrate.

For some applications, alternate forms for feeding solid pellets of a sealant material to the extruder **20** may be provided. For example, as shown in FIGS. **9** and **10**, batch hopper **156** may be mounted on the extruder **20** to supply material pellets, rather than the flexible feed tube **40** discussed earlier. The batch hopper **156** gravity feeds pellets through an elbow tube **166** which is connected with the inlet tube **74**. The size of the batch hopper **156** accommodates a single "batch" which is sufficient to apply sealant to a given part or for a specific job. In order to replenish the batch hopper **156**, the robot **22** swings the extruder **20** to a loading position, in which the hopper **156** is positioned beneath a material dispenser **158**, with a discharge tube **160** of the dispenser **168** extending down into the interior of the hopper **156**, as best seen in FIG. **10**. A motor member **162** which may be electrical, hydraulic or pneumatic, controls a discharge valve diagrammatically indicated by the numeral **164** in order to allow a single batch of material to be dispensed through the discharge tube **160** into the hopper **156**. After a batch of material has been so discharged, the robot **22** lowers the extruder **20** into clearing relationship to the dispenser **158** and discharge tube **160**. As the hopper **156** moves away in this manner, the remaining material within the discharge tube **160**, beneath the valve **164**, flows down and into the hopper **156**.

Attention is now directed to FIGS. **11** and **12** which depict an alternate form of the extruder of the present invention, generally indicated by the numeral **180**. The extruder **180** is similar or identical to the previously described extruder in terms of its component parts; only those parts that may be different than those previously described will be discussed here. The extruder **180** is mounted for limited movement about two orthogonal axes, at a stationery position along an assembly line which includes a conveyor **168**. Conveyor **168** moves parts such as the metal channel part **172** along a path guided by transversely spaced, stationary feed guides **170**. Feed guides **170** precisely control the traverse positioning of the part **172** as it passes by the extruder **180**.

The extruder **180** is pivotably mounted on a pair of spaced apart mounting flanges **186** which are secured to a base **192**. A pair of forwardly extending arms **190** have one end connected to structure supporting the extruder **180**, and the other end connected to the output shaft of a hydraulic or pneumatic cylinder **188** which functions to raise or lower the extrusion die **176**. Counter weights, may be mounted on the opposite end of the extruder **180**, as required, to achieve proper balance. A batch type hopper **178** is provided on the extruder **180** to supply pellets or other solid forms of sealant material. A hot air blower **182** is mounted up stream from the extrusion die **176** to apply hot air at a desired temperature via the exit nozzle **184** to preheat the part **172**.

A guide shoe **174** mounted on a guide arm **194** of the extruder **180** is adapted to be received within a groove or channel in the part **192** and functions to pivot the extruder **180** about a vertical axis, depending upon the traverse position of the channel or groove within the part **172**. In this manner, the shoe **174** acts as a camming guide to precisely move and locate the extrusion die **176** relative to the part channel so that the bead of sealant material is dispensed in precise registration within the groove or channel within the part **172**.

From the foregoing, it may be appreciated that the present invention provides for the reliable accomplishment of the objects of the invention and does so in a particularly effective and economical manner. It is recognized, of course, that those skilled in the art may make various modifications or additions to the preferred embodiments chosen to illustrate the invention without departing from the spirit and scope of the present contributions of the art. Accordingly, it is to be understood that the protection sought and to be afforded hereby should be deemed to extend to the subject matter claimed and all equivalents thereof fairly within the scope of the invention.

What is claimed is:

**1**. An apparatus for extruding a highly viscous material onto a substrate, comprising:
- a housing defining an interior and an inlet opening to the interior at a first end of the housing for receiving material to be extruded and an outlet opening to the interior at a second end or the housing for exiting extruded material;
- a screw rotatably supported within said housing interior and extending between the first end of the housing and the second end of the housing for displacing and compressing the material within the housing;
- a nozzle arrangement including an extrusion die disposed at the second end of the housing defining a die opening through which material is extruded from the housing interior onto the substrate;
- hydraulically operated motor means connecting with the screw;
- means on the housing for heating said material to a desired temperature;
- a pressure sensor carried on the housing at the second end for generating a signal indicative of the pressure of the material at the second end; and
- a controller electrically connected to the hydraulically operated motor means and to the pressure sensor, for generating a control signal in response to the pressure signal and transmitting the control signal to the hydraulically operated motor means.

**2**. The apparatus of claim **1**, including:
- an inlet tube extending from the inlet opening; and
- a swivel feed tube connection fixed to one of an end of a feed tube and an end of the inlet tube and enveloping and rotatably engaging the other of the end of the feed tube and the end of the inlet tube wherein the feed tube end can swivel with respect to the inlet tube.

**3**. The apparatus of claim **1**, including a remote continuous feed system having:
- a remote reservoir for retaining solid pellets of material;
- a vacuum source;
- a vacuum draw tube disposed between the remote reservoir and the vacuum source; and
- a feed tube disposed between the vacuum source and the inlet opening.

**4**. The apparatus of claim **1**, including a discrete localized feed system having a hopper connected to the inlet opening of the extruder with a volume of pellets dispensed into the hopper sufficient for a particular application.

**5**. The apparatus of claim **1**, wherein said nozzle arrangement includes a selectively positionable plurality of extrusion dies.

**6**. The apparatus of claim **1**, including:
- a feed guide establishing a position of a part for movement past the extrusion die; and

a guide shoe fixed relative to the extrusion die and operably engaging the part for movement therealong.

7. The apparatus of claim 1, including:

a hot air blower located downstream of the extrusion die relative to a direction of movement between a substrate and the extrusion die and directing a flow of hot air at the substrate material.



8. The apparatus of claim 5, including a robotic mechanism having a selectively pivotal arm electrically connected to the controller and responsive thereto to which the housing is mounted.

* * * * *

# EXHIBIT C

US005266133A

# United States Patent [19]

Hanley et al.

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[54] **DRY EXPANSIBLE SEALANT AND BAFFLE COMPOSITION AND PRODUCT**

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[58] **Field of Search** .......................... 156/71, 79, 308.4; 521/84.1, 136, 139, 140

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[57] **ABSTRACT**

A dry, initially non-tacky, expansible, shaped and formed sealant and baffle component is provided for sealing and providing an acoustic baffle for cavities in the hollow structural components of a vehicle body or the like, which during the manufacturing operation is conveyed through a bake oven at an elevated temperature. The component is made up of a metal ion neutralized ethylene-$\alpha,\beta$ ethylenically unsaturated carboxylic acid copolymer (ionomer), a blowing agent, and a tackifier, and optionally with an additive polymer and a cross-linking agent. The blowing agent is selected to be activated at the temperature of the bake oven so that the shaped and formed component expands in the body cavity to seal the cavity and prevent ingress of moisture, dust and other contaminating materials and particles, as well as to form a sound barrier therein.

**10 Claims, No Drawings**

## DRY EXPANSIBLE SEALANT AND BAFFLE COMPOSITION AND PRODUCT

### BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a dry, initially non-tacky, heat expansible sealant and baffle composition which is formable into a desired shape so that upon insertion of a sealant product of predetermined shape into a cavity such as the hollow post structure of an automobile or similar vehicle, followed by heat induced expansion thereof, it serves as a highly effective sealant and acoustic baffle within that cavity.

In particular, the invention concerns a heat expansible sealant and baffle composition which after being formed into a desired configuration is adapted to be placed within a vehicle post or other body cavity in a position such that when the vehicle body is subjected to a primer and/or paint baking operation or other process which elevates the temperature of the environment surrounding the vehicle body, the shaped sealant and baffle product expands to an extent that the expanded component serves to attenuate annoying sounds that would otherwise pass through the cavity. The expanded product also functions to seal the cavity and thereby prevent infiltration of moisture, dust, air, other undesirable fluids, and sound.

2. Description of the Prior Art

During the fabrication of automobiles, trucks and similar over-the-road vehicles, many body components present cavities which require sealing to prevent ingress of moisture and contaminants which can cause corrosion of the body parts. This is especially true with respect to unibody structures in which a heavy frame is replaced with a structurally designed space frame that inherently presents a number of moisture and contaminant collecting cavities. These cavities also serve as passages which attenuate noise and other sounds transmitted therethrough during normal use of the vehicle. For example, the upright post structure of a vehicle's body defining a portion of a respective window opening presents an elongated passage or cavity which can collect moisture and contaminants and also transmit annoying sounds unless the passage or cavity is at least partially filled with a sealant material that blocks entrance of moisture and debris, and that also serves as a baffle for muting sounds that would otherwise be transmitted along the length of the passage or cavity. There are other irregular cavities in a vehicle body which desirably are sealed to prevent moisture and contaminants from entering that area and being conveyed to other parts of the interior of the vehicle body.

Many attempts have been made to seal these cavities, including spraying of a sealant into the cavity, introduction of foam products into such cavities, and use of fiberglass matting and the like. These past efforts have not been entirely satisfactory because of the inefficiency of the sealing and baffling methods, the relatively high cost of the sealing process, and the fact that erratic sealing has resulted in many instances.

Foaming in place has not been totally satisfactory because of the difficulty in controlling where the foam travels upon introduction of the foam into a vehicle body cavity or the like, and the fact that more foam than is actually needed is usually introduced into the body cavity to provide some degree of redundancy in preventing entry of moisture into the cavity during use of the vehicle. Furthermore, foams have a finite life insofar as flexibility is concerned before becoming rigid, thus limiting the time available during which the foam may be introduced into the vehicle cavity. In addition, if the interior surface of the cavity had a somewhat oily surface, the foams would not adequately adhere to that surface and provide an effective seal.

Other types of foam or foamable products are tacky in nature and thus cannot readily be positioned at the exact required disposition in the selected cavity. Certain sealant and baffling materials also are sensitive to the elevated temperature conditions to which a vehicle body may be subjected during fabrication of a vehicle thus causing disruption of the sealant and sound attenuating properties of the sealant.

### SUMMARY OF THE INVENTION

It is therefore a primary object of the present invention to provide a dry, initially non-tacky, expansible sealant and baffle composition which expands when heated so that upon shaping and forming of the material into a component of predetermined configuration, that component may then be introduced into a vehicle body cavity or the like in disposition whereby upon elevation of the temperature of the environment surrounding the vehicle body, the component undergoes expansion to the extent that it serves as a sound attenuating barrier and seals the body cavity against infiltration of moisture and air thus preventing internal corrosion.

This principal object of the invention is accomplished by combining predetermined proportions of an ethylene-$\alpha$, $\beta$ethylenically unsaturated carboxylic acid, partially metallic ion neutralized ionomer, a heat activated blowing agent and a tackifier, and that may be formed into a dry, initially non-tacky, expansible sealant and baffle component of a predetermined size and shape. The outer surface of the component is not sticky or tacky when formed and shaped, but becomes tacky upon expansion as a result of elevation of the temperature of the product while positioned within a body cavity to be sealed. As a result, the expansible product adheres to the surface of the structure defining the cavity to be sealed during expansion and remains in place with full sealing being obtained.

A further significant object of the invention is to provide a dry, initially non-tacky, expansible sealant and baffle component for sealing and providing an acoustic baffle for a vehicle body cavity or the like which may be formulated from materials which expand to a required degree at an elevated temperature to which the vehicle body is subjected during at least a part of the manufacturing operation. The vehicles are generally subjected to a high temperature bake cycle, for example, within the range of about 150° C. to 250° C., and preferably about 160° C., in a bake/enamel oven following vehicle body shop work. After interior and exterior seam sealing, underbody coating and application of an exterior paint, the vehicle is directed through a low bake paint oven maintained at a temperature of 115° C. to about 150° C., and preferably about 120° C. Therefore, it is desirable that the expansible sealant and baffle component which is placed in a body cavity to be sealed, be responsive to the elevated temperature encountered in one or more of the baking ovens in order to undergo sufficient foaming to seal and provide an acoustic baffle for the vehicle cavity.

Another important object of the invention is the fact that the materials from which the expansible component is formed do not undergo significant deterioration during their normal life cycle under widely varying moisture and temperature climatic conditions.

Also an important object hereof is to provide a dry, initially non-tacky, expansible sealant and baffle component which is made up of cross-linked polymeric materials that allow selective variation of the degree of cross linking obtained so that the component may be designed to effectively seal any one of a number of structural cavities of differing cross-sectional area and shape, and to expand at a predetermined, specific temperature, within a relatively wide range of temperatures, that may occur in a manufacturing operation.

The invention also relates to a method of sealing and providing an acoustic baffle for a vehicle cavity or the like wherein a seal for such cavity may be obtained by the straightforward steps of simply combining an ionomer, a blowing agent and a tackifier, forming of such combination into a solid block, placing the block thus formed in the cavity to be sealed, and then subjecting the cavity defining structure to an elevated temperature sufficient to effect expansion thereof.

European Patent Application No. 0 383 498 by Exxon Chemical Patents Inc. describes a shaped foamable part which can be used in car pillars or the like that is based on a polymer containing units derived of ethylene and an olefinically unsaturated methyl acrylate (E-Ma). A cross linking agent and a blowing agent are combined with the E-Ma in order to effect foaming and curing of the product at a temperature within the range of 110° C. to 190° C. By virtue of the fact that the E-Ma has a broad molecular weight range, it is not possible to tailor the formulation so that it begins to foam at a particular temperature or relatively narrow temperature range. This means that control over foaming is difficult, if not impractical to obtain, because the different molecular weight fractions melt at different temperatures. When the part to be foamed in place is elevated to the bake oven temperature, that may not result in melting of all portions of the E-Ma, thus, limiting the degree of foaming, or causing non-homogenous and therefore unacceptable expansion and cell size.

By virtue of the utilization of ionomer base polymers which have ionic bonds, it is possible to tailor the sealant and baffle product so that it will undergo melting and consequent expansion at a fairly narrow temperature range. As a consequence, the base polymer uniformly melts at the selected temperature so that complete expansion and substantially uniform cell formation is obtained at the mandated oven bake temperature of the manufacturing process. Furthermore, the more uniform temperature melt profile obtained by use of ionomer type base polymer results in a greater cross linking density in the final expanded baffle and sealant product, not only because of the ionic bonds available along with co-valent bonds, but also because of the greater degree of melting that occurred at time of expansion.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred dry, initially non-tacky, expansible sealant and baffle component in accordance with the present invention is preferably formulated and prepared by first providing a quantity of base polymer. The base polymer, more fully described below, is an ethylene-α-β ethylenically unsaturated carboxylic acid copolymer ionomer composition which has been at least partially neutralized with a metallic ion such as zinc, sodium, potassium, lithium, magnesium, aluminum and strontium.

From about 30 to about 80 parts by weight of this base polymer ionomer is combined with from about 0.1 to about 10 parts by weight of a blowing agent, more fully described below, that is activated only after being subjected to predetermined elevated temperature. The blowing agent is selected to effect expansion of a product containing the ionomer, at a temperature to which the product is subjected during use thereof in a manufacturing process.

It is also desirable that a tackifier constituent more fully described below be added to the combination of the ionomer and blowing agent which imparts tackiness to at least the outer surface of a formed and shaped component prepared from the ionomer-blowing agent combination, only after the temperature of the component has been increased and after it may have undergone some degree of elevated temperature induced expansion. Prior to elevation of the temperature of the shaped component which has been formed from the ionomer-blowing agent combination, the component is dry, and the outer surface thereof is non-tacky. Best results have been obtained when the tackifier constituent causes the outer surface of a component prepared from the ionomer, blowing agent, and tackifier to become sticky and tacky and after the molded component is raised to a temperature sufficient to activate the blowing agent in the formulation. Preferably, from about 1 to about 10 parts by weight of a tackifier may be incorporated into the product formulation.

Other components, as discussed below, may be added.

When the dry, initially non-tacky, expansible sealant and baffle component is to be used for sealing body cavities of a vehicle or the like, it is preferred that the blowing agent initiate expansion of the formed and shaped component at a temperature within a range of from about 100° C. to about 200° C., and desirably from about 115° C. to about 200° C. An especially preferred formulation in this respect includes a blowing agent that is activated at temperature of about 120° C. to 160° C. A dry, initially non-tacky, expansible sealant and baffle formulation for preparing a formed and shaped expansible component especially useful in sealing vehicle body cavities or the like, and that will undergo expansion to a required degree when subjected to a predetermined elevated temperature during a manufacturing operation, may include:

### Base Polymer

The base polymer is a copolymer of ethylene and an α,β ethylenically unsaturated carboxylic acid partially neutralized with a metallic ion. The base polymer is of the formulation E/X/Y, where E is ethylene, X is a carboxylic acid containing 3 to 8 carbon atoms, and Y is an optional alkyl acrylate, alkyl methacrylate, alkyl vinyl ether, carbon monoxide, sulfur dioxide, vinyl acetate, or mixtures thereof, where alkyl groups are 1-12 carbon atoms, and wherein—

the acid groups in X are at least partially neutralized from 5-90%,

E is at least 50 weight % of E/X/Y,

X is 1-35 weight % of E/X/Y, and

Y is 0-49% weight % of E/X/Y.

Illustrative of the $\alpha,\beta$-ethylenically unsaturated carboxylic acids useful in the preparation of said ionic copolymer are acrylic acid, methacrylic acid, ethacrylic acid, itaconic acid, maleic acid, fumaric acid, and monoesters of itaconic acid, maleic acid, and fumaric acid.

It is preferred that the metal be zinc, although useful results can be obtained using other metal cations such as sodium, potassium, lithium, magnesium, aluminum, and strontium in place of zinc. Procedures for preparing these ionomers are described in U.S. Pat. No. 3,264,272 which is incorporated herein by reference thereto.

An especially useful composition is an ionomer made up of metal ion partially neutralized ethylene-methacrylic acid copolymers.

Although the melt index, as measured per ASTM D-1238, is desirably from 0.2 to 14, the ionomer chosen for a particular application should have a melt index that will give a required degree of expansion of the shaped and formed component prepared therefrom.

## Blowing Agent

From about 0.1 part to about 10 parts of an azodicarbonamide, or a benzene-sulfonyl hydrazide is the preferred blowing agent. The hydrazide may be a p,p'-oxybis(benzene-sulfonyl hydrazide), for example, Uniroyal Chemical Celogen® TO, or p-toluene sulfonyl hydrazide sold by Uniroyal Chemical as Celogen® TSH. The desired range of Celogen® TO is preferably from about 2 parts by weight to about 8 parts by weight of the final product, while the range of Celogen® TSH additive is from about 0.1% part to about 5% parts by weight and preferably from about 0.1% part to about 2% parts by weight of the total formulation.

Uniroyal Chemical Celogen® AZ 130 or 3990 azodicarbonamides are suitable blowing agents, as are modified azodicarbonamides such as Uniroyal Chemical Celogen® 754 or Celogen® 765. The Celogen® AZ blowing agents are preferably provided at a level from about 4 parts by weight to about 9 parts by weight of the final product.

The listed blowing agents are preferred because each serves to effect expansion of the sealant and baffle component at an elevated temperature level normally present during passage of the automobile body or other similar cavity defining structure through a bake oven. The temperature of the bake oven in vehicle manufacturing processes is generally of the order of 115° C. to about 200° C.

The preferred blowing agent is of a chemical nature as opposed to a physical blowing agent. The blowing agent may be made up of a combination of agents depending upon the degree of expansion desired for a particular application. Therefore, the choice of blowing agent is dependant upon the desired degree of expansion, the required cell structure, and the automobile or other manufacturers oven bake schedule.

## Tackifiers

It is also preferred that a tackifier be incorporated in the formulation to be molded and shaped into the expansible sealant and baffle component. The tackifier constituent should be of a nature to cause the outer surface of the molded and shaped component to become sticky and tacky upon expansion of the component by the blowing agent, but not of characteristics such that the outer surface of the component exhibits tackiness or is sticky after molding and before expansion of the component. It is therefore desirable that the molded and shaped sealing and baffle component which is to be strategically placed in a cavity that is to be sealed and acoustically baffled, have a dry, initially non-tacky surface. However, the tackifier additive preferably has the property of causing the outer surface of the component to become tacky and sticky when the component is subjected to an elevated temperature sufficient to cause the blowing agent to effect expansion of the component to the preferred 100% to 1500% extent.

In order to enhance the adhesive properties of the base polymer (and any additive polymer included therewith) at the bake temperature to which the sealant and baffle product is subjected, the tackifier constituent desirably should have the following characteristics: a relatively low average number molecular weight, i.e. 3000 or less; no significant crystallinity; a ring and ball softening point of at least about 50° C and preferably higher than that value; and that is compatible with the base polymer and/or the additive polymer. Compatibility in this respect can be determined by preparing a blend at a temperature of about 350° F of the tackifier and base polymer/additive polymer formulation, pouring of the blend onto a support surface to form a relatively thin layer, and to then determine the flexibility of that sheet at room temperature. The materials should exhibit no cracking or stress whitening and flex freely without cracking when bent. To achieve compatibility, the acid functionality of the tackifier constituent can be adjusted.

From about 1 to about 10 parts by weight of the tackifier should be included in the formulation. Exemplary tackifiers in this respect include: alkyl phenol-formaldehyde novolak resin (Akrochem® P-90); partially polymerized (dimerized) rosin (Hercules Polypale® rosin); pentaerythritol ester of disproportioned tall oil rosin (Arizona Chemical Zonester® 65 having a melting point of 65° C.); hydrogenated pentaerythritol ester rosin (Hercules Pentalyn® H); low molecular weight, non-polar, aromatic (petroleum-derived monomers) thermoplastic resin (Hercules Picco® 5000 and 6000 series aromatic hydrocarbon resins, in particularly the 5100 and 6100resins having a ring and ball temperature of 100° C.); glycerol ester of rosin (Hercules Vinsol® Ester Gum); and octylphenol-formaldehyde phenolic resin (PMC Specialties Group, Inc. Dyphene® 8313.)

Particularly useful tackifiers comprise $\alpha$-methyl styrene polymers of the type available from Amoco and identified as Resin 18-XXX. The specific numbers substituted for "XXX" in the resin designations indicate the approximate softening point in degrees fahrenheit (ring and ball value) of the specific resin. For example, Resin 18–210 has a softening point of 210° F., Resin 18–240 has a softening point of 245° F., and Resin 18–290 has a softening point of 286° F. The viscosity of AmoCo Resin 18–210 on the Gardner-Holdt (40% toluene) scale is J-L, Resin 18–240 is U-V, and Resin 18–290 is Z-Z: The molecular weight (Mechrolab) of Resin 18–210 is 685, Resin 18–240 is 790 and Resin 18–290 is 960.

A number of tackifying resins having a wide variety of melting points are useful in the polymer composition of the present invention. For example, in the case of Hercules Picco® 6100, the "100" in the designator indicates the ring and ball of the polymeric material. When this tackifier is blended with the preferred ethylene-$\alpha,\beta$ ethylenically unsaturated, carboxylic acid partially metal ion neutralized ionomer and an ethylene methacrylic acid or ethylene vinyl acetate additive polymer if present (both having a melting point of about

85° C.), a physical polymer matrix is formed. When the admixture is a solid, the thermoplastic characteristics are dominant. As the temperature of the material is increased to a level above about 100° C. (as for example, in a car manufacturer's paint/primer baking and/or curing oven), melting of the tackifier begins to occur. Thus, the liquid tackifying resin or polymer is able to wet out the metal substrates surrounding the expansible sealant and baffle product.

If desired, combinations of the listed tackifiers may be incorporated in the sealant and acoustic baffle formulation. In most instances, no more than about three of the tackifiers are used in the combination.

## Optional Additive Polymers

Additive polymers may optionally be incorporated in the sealant and acoustic baffle formulation, with a cross-linking agent then being added to couple the additive with the ionomer base polymer. An additive polymer(s) is added to the sealant and baffle formulation to increase the melt index thereof, so long as the copolymer is compatible with the ionomer base polymer, and provided the cost of such additive polymer is within a practical range.

Each of the additive polymers preferably is of the formulation E/X/Y where E is ethylene, X is a carboxylic acid containing 3 to 8 carbon atoms, and Y is an alkyl acrylate, aklyl methacrylate, alkyl vinyl ether, carbon monoxide, sulfur dioxide, vinyl acetate or mixture thereof, where the alkyl groups are 1-12 carbon atoms, and wherein—

E is at least 50 weight % of E/X/Y,
X is 0-35 weight % of E/X/Y, and
Y is 0-45 weight % of E/X/Y.

The preferred additive polymers are chosen from the group consisting of ethylene methacrylic acid polymers, or ethylene vinyl acetate polymers. Two or more additive polymers may be present. Each additive polymer may be present in an amount of from about 1 part to about 20 parts by weight. Preferably about 10 parts to 20 parts by weight of an additive polymer of the composition ethylene/methacrylic acid, and about 1 part to 20 parts by weight of an additive polymer of the composition ethylene/vinyl acetate having a melt index of about 10 to about 500 per ASTM D-1238.

The additive polymer serves to increase the overall flexibility of the sealant and baffle component upon expansion thereof within a structural cavity, provide directional expansion control, imparts melt control as well as cell control, and increases cold impact resistance.

The quantity of additive polymer added is related to and dependant to a certain extent upon the proportion of an optional filler that may be added.

The preferred additive polymer is Nucrel® 599 which has a melt index of 500 per ASTM D-1238. Nucrel® 599 is a copolymer of 90 weight % ethylene and 10 weight % MAA based on total additive polymer (E/10%MAA).

When ethylene-vinyl acetate (EVA) is utilized as the additive polymer, the EVA chosen should have a melt index of from about 10 to about 500. Again, the quantity added (from about 1 part by weight to about 20 parts by weight) is largely a function of the amount of filler added to the formulation.

Styrene type rubbers may also be used as an additive polymer, as for example, styrene-butadiene-styrene block polymers, styrene-isoprene-styrene block polymers, and styrene-ethylene/butylene-styrene block polymers, or slightly cross-linked, styrene-butadiene type synthetic rubbers sold under the trade designation Ameripol Synpol SBR 1009. Preferably these styrene type rubbers would be added in an amount of about 1 part to about 10 parts and more preferably from about 2 parts to about 5 parts of the block polymers and in an amount of from about 1 part to about 10 parts and more preferably from about 1 part to about 4 parts of the SBR type rubber.

## Cross-Linking Agent

A cross-linking agent is normally incorporated in the formulation in those instances where an additive polymer is added in order to further cross-link the polymers during the bake cycle, and to increase the degree of curing of the polymers. Any free radical initiator cross-linking agent that is compatible with the ionomer base polymer and the additive polymer may be utilized in the present formulation, although a peroxide based cross-linking agent is preferred. A,a'-bis(t-butylperoxy) diisopropylbenzenes (40%) on clay are the most preferred (e.g., Akrochem Retilox® F 40 KEP) cross-linking agents, although Volkup® 40 KE and peroxides such as dicumyl peroxide (Dicup® 40 P) have also been found to be satisfactory. In most instances, from about 1 part to about 5 parts by weight of the peroxide cross-linking agent is provided in the sealant and acoustic baffle formulation.

## Activators

Optionally, an activator may be included in the sealant and acoustic baffle formulation for the purpose of reducing the temperature of activation of the chemical blowing agent, or the combination of such agents. Specifically, an activator such as a surface coated, oil treated urea (Uniroyal Chemical BIK® TO) may be added to the formulation with from about 1 part to about 5 parts by weight, and desirably from about 1 part to about 2 parts by weight of the BIK TO activator being provided in the sealant and acoustic baffle component.

Zinc oxide may also be incorporated in the formulation as an activator with the range of incorporation being from about 1 part to about 5 parts by weight and desirably from about 0.5 part to about 2 parts by weight of the ZnO being provided in the sealant and baffle formulation.

Other optional activators include from about 1 part to about 5 parts by weight of calcium and/or zinc stearate, or polyethylene glycol in the expansible sealant and baffle component.

The amount of activator for the blowing agent(s) which is added is depended upon the degree of expansion required of the sealant and baffle product. For example, a composition which is formulated to expand about 400% will require one type of activation system, while a composition formulated to expand 1,000% will have a different activation system, as is common knowledge to formulators of expandable materials.

## Plasticizers

Another optional component in the formulation is a plasticizer to soften the polymer matrix and reduce the melting point of the ionomer(s). The plasticizer may be present in an amount from about 1 part to about 15 parts by weight in the sealant and acoustic baffle component. A preferred plasticizer is diisooctylphthalate (DIOP).

Other useful plasticizers include DNIP, DIDP and naphthenic oils. The amount of the plasticizer included is dependant upon the quantity of rubber co-polymer added, and the filler concentration.

### Fillers

If desired, fillers may also be added to the sealant and acoustic baffle formulations. From about 1 part to about 20 parts by weight of calcium carbonate (Thomasville Regency #7) or barium sulfate (Cyprus #22 Barytes) may be included in the expansible sealant and baffle component.

### Adhesion Promoters

Additives may be incorporated in the formulation to further improve adhesion of the expanded component to certain substrates. Exemplary adhesion promoters include the organosilanes, carboxylated resins, resins containing maleic anhydride, and similar materials. From about 1 part to about 5 parts by weight of the promoter is normally adequate.

### Pigments

Pigments can be added to the formulation to meet a particular customers specifications. Generally, the amount of the pigment(s) will be within the range from about 1 part to about 5 parts by weight and may include carbon black, titanium dioxide, or other compatible colored pigments.

### EXAMPLE 1

Preparation of a composition useful for preparing a sealant and baffle product having the desired characteristics of the present invention is preferably carried out by adding the ionomer material, the tackifying resin, and additive polymers and rubber type materials if used, to a clean high intensity mixer such as a Banbury-type mixer, or a high shear mixer such as a Baker/Perkins-type mixer. The constituents are mixed in the mixing vessel under high shear until a homogenous admixture is obtained.

Any fillers that are to be incorporated into the composition are then added to the mixer, along with adhesion promoters and any optional pigments. Again, the constituents are subjected to high shear while being mixed until a homogenous admixture is attained.

A coolant at a suitable temperature level should be directed into the coils or heat exchange surfaces of the mixer for a time period as may be required to assure that the temperature of the composition in the mixture does not exceed a level of about 95° C. and preferably no more than about 80° C., before blowing and curing agents are added to the mixer. If the blowing and curing agents were added at a temperature above the indicated maximum level, premature expansion and cross-linking could occur, thus, making the material unusable.

After it has been determined that the temperature of the composition in the mixture does not exceed the maximum 95° C. level, and desirably no more than about 80° C., the blowing agent(s), accelerator(s), cross-linking agent(s), and plasticizer(s) if used are added to the mixer and subjected to high intensity shear for 3 to 5 minutes.

The material is thereafter removed from the mixer and processed through a two-roll mill maintained at a temperature of about 55° C. to cool the admixture.

The resulting bulk composition is then subjected to a pelletizing operation, or extruded into sheet stock, rods or sticks, or a simple continuous form. The extruded material is then subjected to a pelletizing step. "Pelletizing" in this context means subjecting the bulk material out of the mixer, or the extruded shapes, to a process such as grinding, cutting, or any equivalent function which reduces the size of the composition into small pellets which can flow easily into an extruder or molder. The beads resulting from the pelletizing step normally will be about ⅛ inch in diameter.

As a specific example of the invention, the following materials were admixed in a Banbury mixer for a time period sufficient to obtain a homogeneous product.

### EXAMPLE 1

| Manufacture | Raw Material | % by Weight |
|---|---|---|
| DuPont | Surlyn ® 9970 | 54.0% |
| DuPont | Nucrel ® 599 | 10.0% |
| Ameripol | SBR 1009 | 2.0% |
| Hercules | Picco 6100 | 7.5% |
| Pfizer | Ultrapflex $CaCO_3$ | 12.0% |
| Ricon Resins | Ricon 156C | 3.0% |
| Uniroyal | Celogen AZ-130 | 4.9% |
| Uniroyal | Celogen OT | 2.1% |
| Akrochem | Zinc Oxide | 1.5% |
| Akrochem | Peroximon DC-40P | 3.0% |

The formulation of this example will expand about 400% when subjected to a temperature sufficient to activate the blowing agent therein.

### EXAMPLE 2

Other suitable formulations include the following:

| Mfg. | Raw Material | Batch 1 | Batch 2 | Batch 3 | Batch 4 |
|---|---|---|---|---|---|
| DuPont | Surlyn ® 9450[1] | 64.00% | 64.00% | 64.00% | 64.00% |
| DuPont | Nucrel ® 010[2] | 16.00% | 16.00% | 16.00% | 16.00% |
| Arizona Chemical | Zonester 65 | 6.00% | 6.00% | 6.00% | 9.00% |
| Thomasville | Regency #7 $CaCO_3$ | 3.50% | 3.00% | 3.00% | ***** |
| Uniroyal | Celogen ® AZ-130 | 3.50% | 3.50% | ***** | 3.50% |
| Uniroyal | Celogen ® OT | 3.50% | 3.50% | 7.00% | 3.50% |
| Uniroyal | BIK OT | 0.25% | 0.50% | 0.50% | 0.50% |
| | ZnO | 0.25% | 0.50% | 0.50% | 0.50% |
| Akrochem | Volkup 40 KE Peroxide | 3.00% | 3.00% | 3.00% | 3.00% |
| | | 100.00% | 100.00% | 100.00% | 100.00% |

[1]SURLYN ® 9450 is a co-polymer of 91 weight % ethylene and 9 weight % methacrylic acid based on total polymer (E/9% MAA), 18% neutralized with Zn.
[2]NUCREL ® 010 is a co-polymer of 80 weight % ethylene/10 weight % butyl acrylate/10 weight % methacrylic acid with a melt index of 10.

### EXAMPLE 3

The following materials were admixed in a Banbury mixer for a time period sufficient to obtain a homogeneous product.

| | | Example 3 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Raw Material | | Formula 1 | Formula 2 | Formula 3 | Formula 4 | Formula 5 | Formula 6 | Formula 7 | Formula 8 | Formula 9 | Formula 10 |
| Surlyn ® 9450[3] | | 80.0% | 79.0% | 80.5% | 64.0% | 64.0% | 52.0% | | | | |
| Surlyn ® 9950[4] | | | | | | | | 64.0% | | | |
| Surlyn ® 9970[5] | | | | | 16.0% | | | | 64.0% | 64.0% | 60.0% |
| Nucrel ® 010[6] | | | | | | 16.0% | 28.0% | 16.0% | | | |
| Nucrel ® 599[7] | | | | | | | | | 16.0% | 16.0% | 15.0% |
| SBR 1009 | | | | | | | | | | | 5.0% |
| Tackifying resin | | 6.0% | 6.0% | 5.9% | 6.0% | 6.0% | 6.0% | 6.0% | 9.5% | 10.0% | 9.5% |
| Calcium Carbonate | | 3.0% | 3.0% | 4.4% | 3.5% | 3.5% | 3.5% | | | | |
| Kevlar ® Fiber/Talc | | | | | | | | 3.5% | | | |
| Celogen ® AZ | | 7.0% | 7.0% | 4.9% | 4.0% | 3.5% | 3.5% | | 4.9% | 4.9% | 4.9% |
| Celogen ® OT | | | | | 3.0% | 3.5% | 3.5% | 7.0% | 2.1% | 2.1% | 2.1% |
| Urea | | 1.0% | 1.0% | 0.7% | 0.3% | 0.3% | 0.3% | 0.3% | | 0.3% | |
| Zinc Oxide | | | 1.0% | 0.7% | 0.3% | 0.3% | 0.3% | 0.3% | 1.5% | 0.7% | 1.5% |
| Volkup ® 40 KE | | 3.0% | 3.0% | 2.9% | 3.0% | 3.0% | 3.0% | 3.0% | 1.5% | | |
| Dicup ® 40 P | | | | | | | | | 0.5% | 2.0% | 2.0% |
| Total | | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Testing/Opinions | | | | | | | | | | | |
| Expansion Volume[8] 30 in. @ 325° F. | Mean | 422.2% | 934.7% | 587.0% | 222.1% | 275.8% | 270.4% | 293.0% | 353.7% | 344.0% | 440.2% |
| | St. Dev. | 13.2% | 100.1% | 44.7% | 19.4% | 59.3% | 26.2% | 53.5% | 43.5% | 21.7% | 38.6% |
| Vertical[9] | Mean | 242.4% | 493.7% | 798.2% | 140.8% | 210.1% | 156.2% | 214.0% | 299.6% | 273.2% | 341.9% |
| | St. Dev. | 31.8% | 40.2% | 100.5% | 9.8% | 11.0% | 16.9% | 21.2% | 16.2% | 17.3% | 13.4% |
| Volume[8] 30 in. @ 350° F. | Mean | NT | NT | NT | NT | NT | NT | NT | 700.4% | 663.0% | 591.1% |
| | St. Dev. | NT | NT | NT | NT | NT | NT | NT | 51.8% | 20.0% | 59.4% |
| Vertical[9] | Mean | NT | NT | NT | NT | NT | NT | NT | 447.7% | 367.9% | 394.4% |
| | St. Dev. | NT | NT | NT | NT | NT | NT | NT | 11.1% | 15.5% | 8.7% |
| Comments | | 1st Batch with metal adhesion. | | | | | | | Dual bakes for specific auto plant. | Dual bakes for specific auto plant. | Dual bakes for specific auto plant. |

[3]SURLYN ® 9450 is a co-polymer of 91 weight % ethylene and 9 weight % methacrylic acid based on total polymer (E/9% MAA), 18% neutralized with Zn, with a melt index of 5.
[4]SURLYN ® 9950 is E/15% MAA 23% neutralized with zinc with a melt index of 5.5.
[5]SURLYN ® 9970 is E/15% MAA 22% neturalized with zinc with a melt index of 14.
[6]NUCREL ® 010 is a co-polymer of 80 weight % ethylene/10 weight % butyl acrylate/10 weight % methacrylic acid with a melt index of 10.
[7]NUCREL ® 599 is a co-polymer of 90 weight % ethylene/10 weight % methacrylic acid with a melt index of 500.
[8]Tested according to General Motors Specification GM9037P
[9]Tested according to General Motors Specification GM9764P

A selected formulation from the preceding examples may be molded into a desired shape dependant upon the volume of the cavity to be sealed and baffled, and the configuration of that cavity, to assure that the formed component will fully expand into sealing relationship to the structural sidewalls and thereby prevent ingress of moisture, dirt and other undesirable materials.

The amount of expansion the material should exhibit is normally specified by the OEM manufacturers material specifications. The specifications are written to take into consideration weight required for the part, the area that requires sealing, and stresses imposed by the material on the structure being sealed while expanding in the baffle area. For example, in the case of automobiles, the upright tubular pillars on one side of the vehicle making up the vertical windshield frame, the intermediate pillar between the front and rear side windows, and the rear pillar are conventionally referred to as the A, B and C pillars, respectively. A pillar is a support member between the outer skin of the vehicle and support structure on the inside of the vehicle. These pillars vary in size and shape from vehicle to vehicle. It is desirable though that a sealant and baffle composition be incorporated in the tubular interior of these pillars to exclude sound and moisture incursion. In the case of a composition formulated in accordance with Example 1 above, which has an expansion value of 400%, a 75 mm$\times$75 mm pillar may be sealed to an extent of $5.0\times10^{-4}$ $m^3$ area using a formed component that weighs 140 grams.

The actual size and shape of a sealant and baffle component of this invention to be used in sealing structures such as an automobile pillar, or other similar structure is often dictated by the user for a particular application, depending upon the nature of the structure to be sealed and the amount of expansion of the product when heated that is specified by the OEM manufacturer. In this respect, if the expansible ionomer product of this invention is molded, such as by injection molding, very intricate parts can be made. This enables the sealant and baffle and product to be engineered to operate at a maximum performance with the least amount of material.

Various techniques may be employed to secure the expansible ionomer sealant and baffle product in a desired location within the structure to be sealed before raising of the temperature of the product to a level to effect expansion thereof. In certain instances, the structure to be sealed has structural parts which will support the component in a desired location, particularly if the sealant and baffle product has been molded to a predetermined shape for that application. Other attachment

means may be employed such as fasteners forming a part of the structure to be sealed, or fastening agents incorporated into the molded sealant and baffle product.

Application areas for the sealant and baffle composition of this invention in the automotive industry include both the body shop where metal fabrication, welding and body shop sealers are applied, as well as the down the line paint shop where interior and exterior seam sealing and underbody coating are also carried out in conjunction with application of exterior coatings. The vehicles are generally subjected to a high bake temperature from 150° C. to about 200° C. in the E (enamel)-coat/primer oven immediately following the body shop operations, and to a low temperature of from about 115° C. to about 149° C. in the paint oven. The component is placed in the structural cavity of the body, prior to conveyance of the vehicle body through the bake oven.

One vehicle manufacturer uses a high bake/enamel cycle wherein the vehicle is subjected to a temperature of 157° C. for 25 minutes and a second 25 minute paint oven bake cycle at 115° C. Another manufacturer utilizes a high bake cycle of 20 minutes at 163° C. and a 30 minute low bake cycle at 121° C.

Thus, the constituents making up the expansible sealant and baffle product, and particularly the blowing agent are chosen to assure expansion of the component to a desired degree and to a required extent for sealing a particular cavity of the vehicle body, when the vehicle is conveyed through a particular baking oven at a selectively controlled high or low bake temperature.

It has been found that the ionomer sealant and baffle composition of this invention exhibits superior sound attenuation as compared with other plastic/rubber foam systems at a significantly lower specific gravity. A lighter product made up of less material may therefore be used at an equal or greater sound attenuation than is the case with materials such as conventional rubber and other thermoplastic materials. The ionomer sealant and baffle composition hereof also has been found to have improved initial adhesion characteristics as compared with adhesion of conventional rubber and thermoplastic materials to metals typically used in original automobile manufacturing. The corrosion prevention properties of the ionomer sealant and baffle composition of this invention have also been found to be better than those properties of conventional foam sealants when used with the same metals. Also, the water absorption properties of the present ionomer sealant and baffle composition are far superior to previously available rubber and thermoplastic foams used for sealing purposes.

An important feature of the invention is the fact that the outer surface of the expansible sealant and acoustic baffle component becomes tacky during heating thereof in the bake cycle, so that the component during expansion comes into engagement with the structural component to be sealed, thereby providing a moisture impervious barrier, as well as serving as an acoustic baffle upon final cooling of the baffle and sealant material. Furthermore, materials may be chosen which in combination cause the component to expand to a required extent in the preferred range of from about 100% to about 1500% greater than the original volume of the expansible sealant and baffle component.

We claim:

1. A method of sealing and providing an acoustic baffle for structure defining an area which is at least partially enclosed and that is subjected to a predetermined elevated temperature during a manufacturing operation, comprising the steps of:

combining —

from about 30 to about 80 parts by weight of an ethylene-$\alpha,\beta$ ethylenically unsaturated carboxylic acid copolymer composition which has been at least partially neutralized with a metallic ion, and that has a melt index range of from about 0.2 to about 14,

from about 0.1 to about 10 parts by weight of a heat activated blowing agent capable of increasing the volume of the composition, and

a sufficient amount of a tackifier constituent to impart tackiness to at least the outer surface of the component when it is subjected to said elevated temperature;

forming and shaping the combination of said composition, the agent, and the constituent into a dry, initially solid, non-tacky component;

introducing said component into said area; and

subjecting the component to said temperature, so that the component expands to an extent and the tackifier in association with the composition causes at least the outer surface of the component to become tacky and thereby adhesively bond to the surface of the structure defining said area, the expanded component sealing the area of the structure to present a baffle which substantially prevents infiltration of moisture and air and attenuates annoying sounds.

2. A method as set forth in claim 1, wherein said metallic ion is zinc, sodium, potassium, lithium, magnesium, aluminum, and strontium.

3. A method as set forth in claim 1, wherein is included the step of adding an ionomer composition made up of partially neutralized ethylene-methacrylic acid copolymer.

4. A method as set forth in claim 1, wherein is included the step of adding a blowing agent which is activated at a temperature within the range of about 100° C. to about 200° C.

5. A method as set forth in claim 1, wherein is included the step of adding a sufficient amount of said blowing agent is to cause an increase in the volume of the component when raised to said elevated temperature, of from about 100% to about 1500%.

6. A method as set forth in claim 1, wherein is included the step of adding from about 1 to about 10 parts by weight of an additive polymer to the combination of said composition, the blowing agent and said constituent.

7. A method as set forth in claim 1, wherein said additive polymer is selected from the group consisting of ethylene-methacrylic acid polymer, ethylene-vinyl acetate, and styrene-butadiene polymer cross linked with divinyl benzene.

8. A method as set forth in claim 6, wherein is included the step of adding from about 1 to about 5 parts by weight of a cross-linking agent to the combination of said composition, the blowing agent, the constituent and said additive polymer.

9. A method as set forth in claim 8, wherein said cross-linking agent is a free radical initiator.

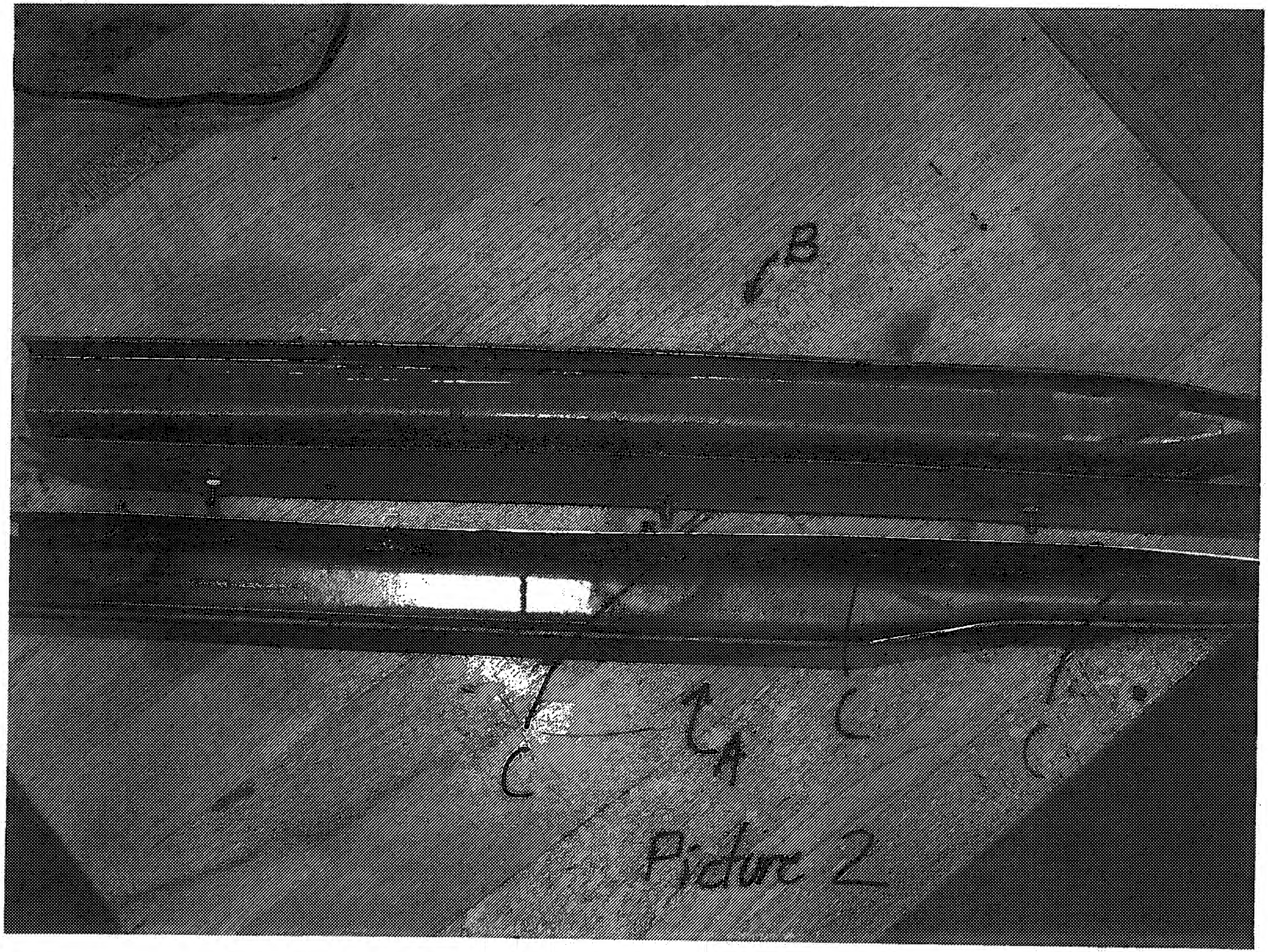
10. A method as set forth in claim 1, wherein is included the step of adding a sufficient amount of said blowing agent to the combination of said composition, blowing agent and constituent to cause the component to increase in volume from about 100% to about 1500% when the component is subjected to said elevated temperature.

* * * * *

# EXHIBIT D


Picture 1

# EXHIBIT E


B
C
A
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Picture 2

EXHIBIT F

L&L Products®

*Engineered Sealing and Structur*
*for the Worldwide Automoti*

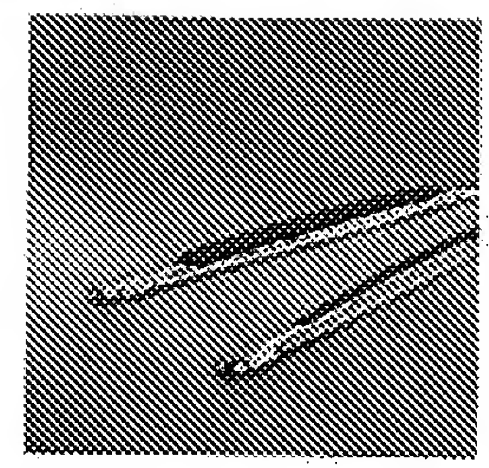
Aerospace Documentation


**Information**

- Home
- Material Science & Engineering
- Service & Manufacturing Expertise
- Past, Present, Future
- Sealing & Acoustic Solutions / 1
- Sealing & Acoustic Solutions / 2
- Structural Reinforcement / 1
- Structural Reinforcement / 2
- Worldwide Service
- Worldwide Contact

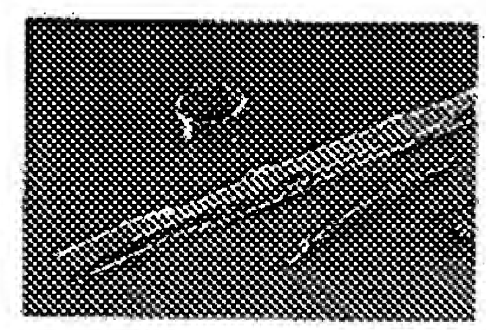

**Sealing & Acoustic solutions / 2**

# *Customer solutions*

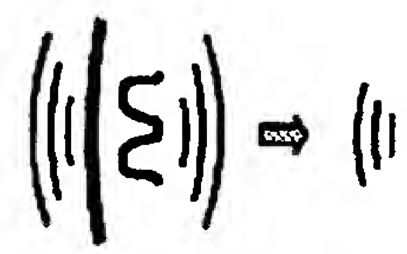
### eXtrude In Place

XIP marries the robustness of the material technology developed by L&L Products and the capability of being a fully automated process. The material is applied directly and precisely onto the metal substrates by a robotized extruder. The result is little to no waste and no tooling required. The material is dry to touch immediately after application. To optimize the logistic flow, we can design and install an XIP system that would be customized to fit in the logistic flow between the stamper and the OEM.



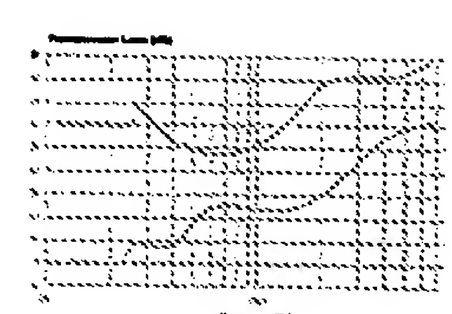
### Versatile sealing technology

This ability to apply materials acurately and precisely to the right location coupled with custom formulated chemical components make XIP a versatile sealing technology. Water, air leakage and vapor intrusion into vehicle compartments can be eliminated with the use of expandable sealant. Current applications include fuel filler, hinge pocket, rear lamp and pillar closures.



### Acoustics improvement

Applied to door beams or roof bows, XIP technology drastically improves the acoustics by damping vibration. The expandable material features damping properties and ties all the individual components together. The XIP application of the material directly on the substrate makes it a cost effective and high performance solution. Silent Beam® is XIP.



### Sound Management

L&L Products provides outstanding acoustic solutions. Our material scientists have formulated foams with noise absorption capabilities and we developed a CAE methodology to design the best combination of material and carrier design.

### Noise absorption

Our company has an extensive range of innovative materials with absorption coefficient alpha(0°) up to standard sealing material reaches only 20%. We collect a full range of data to characterize our materials

- damping ability

- dynamical rigidity
- transmission loss
- air flow resistivity
- porosity

### Virtual development

CAE simulation allows further optimization of acoustic performance of our baffles. Various geometries (i track, sandwich, layer), different carrier materials and different thicknesses are simulated easily using a softwares.

SilentBeam®
TECHNOLOGY